Operational Data to Stimulate Simulation Systems and Enhance Training

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ABSTRACT

For years, the use of simulation by smaller countries has been marked by the saying, "it is very expensive to be poor." In contrast to the larger coalition partners or the budgets of a potential adversary, smaller countries have fractional military budgets; this makes it difficult to acquire the same assets as larger partners. When it comes to training, the utility of simulation is acknowledged, but spending, particularly in smaller countries, is often appropriately prioritized elsewhere. This leads to an approach where simulation is expected to alleviate training constraints, but must do it from a fixed amount of limited funds. Though this approach results in an inherent drawback based on the amount of resources used to setup and execute the training as well as to connect virtual / constructive simulation models to existing Command and Control (C2) systems. This requires trained technicians, and trained support personnel, all of which can exceed the number of personnel in the training audience.

This support staff-heavy model can be changed. This paper will describe techniques to utilize existing data previously generated by the training audience to enhance their training potential, while actually minimizing the amount of support personnel required for a training instance. It will additionally describe a recent use case where the Danish Army, during a military demonstration and assessment, tested the first steps in merging the C2 real world with simulation, going from live to virtual and back. Although not fully scaled, it showed how to merge live and virtual in a cost effective way. Executed successfully and at a larger scale, similar techniques will lead to a future where information flows freely between tactical C2 systems and virtual/constructive simulation models. This will create better, more affordable, solution-focused training that will benefit future soldiers in a practical and measurable way.

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INTRODUCTION

In the year 1864, Denmark lost the Battle of Dybbøl and ultimately the war, crippling the country for decades. One of the significant reasons for the defeat was a heavy reliance on old technology and an inability to embrace new technology (Nielsen, 1987). The muzzle loading rifle was thought to be a superior weapon. It was accurate, battle tested, and had been used for many years as compared to the unproven breech loading rifle. There was little obvious incentive to invest money in new untested technology and concepts when the old systems worked. While an effective cost saving measure, the accuracy of the muzzle loaders was overwhelmed by the sheer volume of bullets fired by the German breech loaders.

In the present day, we continue to embrace a familiar tendency to adhere to known and proven prior experiences, which does not involve the complication of resource limitations. In contrast to the larger coalition partners or the budgets of a potential adversary, smaller countries have fractional military budgets; this makes it difficult to acquire the same assets as larger partners or to upgrade systems as often. Our national objectives for training are continued competency and growth of warfighter skills, continued performance of our humanitarian assistance missions, support to the Afghanistan mission, and defense of Greenland (Danish Government, 2012); that is a broad task set to train to with limited resources. When it comes to training, the utility of simulation is acknowledged, but spending, (particularly in smaller countries) is often appropriately prioritized elsewhere. This leads to an approach where simulation is expected to alleviate training constraints, but must do it from limited funds. This approach results in an inherent drawback based on the amount of resources used to setup and execute the training, and to connect virtual / constructive simulation models to existing Command and Control (C2) systems (Johansen & Voss, 2012). This requires trained technicians and trained support personnel, all of which can exceed the number of personnel in the training audience.

This support staff-heavy model can and must be changed if we want to maximize outcomes without a budget increase. This paper will describe techniques to utilize existing data previously generated by the training audience to enhance the training potential while actually minimizing the support personnel required for a training instance. It will additionally describe a recent use case where the Danish Army, during a military demonstration and assessment, tested the first steps in merging real C2 with simulation, going from live to virtual and back. Although not fully scaled, it proved the potential for existing systems to inexpensively merge live and virtual in a cost-effective way. Executed successfully and at a larger scale, similar techniques will lead to a future where information flows freely between tactical C2 systems and virtual/constructive simulation models. This will create better and more affordable solution-focused training which will benefit future soldiers in a practical and measurable way

THE WAY IT IS

The Danish Army uses simulation to train skills that are prohibitively expensive to practice in the field. This includes training that requires large amounts of ammunition, vehicles, and aircraft, or challenging and specific environments. In a world of limited budgets, safety, convenience, and cost savings make simulation an attractive option; however, providing quality impactful simulation-based training typically requires a large number of support staff, i.e. "pucksters", to drive the systems and execute tasks that are not currently smoothly automated. In this paper, we will use the term "puckster" to represent a lower control simulations operator. We only use this term to represent the fact that, in most countries with a low military budget, using the term Simulations operator elevates the operator to a soldier proficient in Simulations operating, which in Denmark is not the case. The Simulations operator, or puckster in this case, is usually a soldier with the rank of private, often with no simulations experience prior to execution of the training at hand. As an example, a brigade staff exercise might require 60 dedicated pucksters to provide high fidelity training for a 20- to 30-person brigade staff who use their C2 systems to interact with the puckster-run simulation systems. The puckster driven simulations are required to provide lower unit information into the staff's command and control systems, but there is little value to the supporting personnel themselves.

Artillery observer training offers another example of such support staff–heavy intervention. An artillery observer's Battle Management System transmits data to the Joint Fires Cell about enemy and friendly positions as well as other information critical for targeting. The Joint Fires Cell handles the data inside of their own C2 software before passing it digitally on for further work to the Joint Fires Coordination Cell. In the military, Command, Control, Communications & Computers Information Systems (C4IS) are the major focus; in the current operational environment, computer systems and applications are increasingly utilized by soldiers to manage, command, and operate alongside subordinate units. This produces a massive amount of data freely flowing on headquarter level networks and on the tactical networks in the field representing data that covers various classification levels. Today, this type of information is passed by voice in simulation, and each artillery observer in-training requires at least one puckster to point-and-click in the simulation to execute artillery detonations. This soldier also acts as the Joint Fires Cell, but does not perform any actual Joint Fires Cell tasks apart from responding to radio communications. The soldier acting as the puckster receives next-to-no training during this event; they are a training aid. If we add more artillery observers or a forward air controller to the scenario, we need another soldier to "play" the Joint Fires Coordination Cell (again, only operating voice communications for the additional participants). With every puckster added to the scenario, the cost of the training goes up both in terms of subject matter experts (SME) and soldiers to support running the scenario and troubleshooting the environment. This structural inefficiency is where the money-saving efficiency of simulation becomes lost.

To further complicate matters, having professional pucksters for friendly or opposing forces might not be an option in a country with a limited budget; instead, both SME and soldier pucksters are typically trained in using the simulation model for the specific venue/task when and if time is available prior to training execution (Colonna-Romano, Stacy, Weston, Roberts, Becker, Fox, & Paull, 2009). This normally results in a superficial understanding and barely adequate ability to complete the task. Simulation-based training can easily reach a point where it becomes complex, detailed, and requires a high degree of military skill – a point at which the novice-level pucksters can no longer provide adequate training support.

This need for more trained support staff can be mitigated by using data already produced by the training audience to stimulate the simulation. This position, i.e. the reuse of tactical data from the operational environment, has been highlighted by many US military organizations as a need (O'Connell, R., Citizen, J., Nolan, J, and Cerri, T. 2016). It provides a richness to the environment that is seldom pre-loaded into scenarios, providing the reality of unpredictable ground forces and the cluttered signals and information environment they are expected to operate in after training.

WHAT IT SHOULD BE

In the near future, a staff officer will sit down with his mission documents, the Order of Battle (ORBAT) for his or her own forces, and the expected enemy ORBAT, and proceed to make decisions based on assumptions attached to each ORBAT. That officer will then design plans. These pieces of information will be input into his C2 systems as usual prior to mission execution, but the data will also populate a supporting simulation. A puckster is not needed to add the units and graphics into the simulation; during execution, the units automatically move within the simulation according to the plan. With interconnection between the C2 system and the simulation, the staff is then able to train on their actual systems with the simulation invisible to them.

This staff officer in a brigade exercise is only one of 15 personnel performing these same tasks, writing plans for their staff areas. They are each plotting a minor part of a major plan. The scale of the issue we currently face now becomes apparent, as pucksters must perform translation duties for each staff officer, taking the plans built in C2 systems and converting them by hand into the simulation systems. In this ideal scenario, each staff officer focuses on their own branch rather than on translating information to a puckster. Training realism remains strong and less time is spent smoothing through artificialities.

That is tomorrow. For now, in a brigade command post exercise using Joint Conflict and Tactical Simulation (JCATS) as the simulation model, the brigade staff have made their plans in a C2 system complete with tactical graphics. In order to proceed, pucksters have to manually draw these graphics to the JCATS Graphics User Interface (GUI) for their own reference. When communicating military plans, a misunderstanding of unit placement or misrepresentation of a few hundred feet on the map can change the course of battle when the simulation is executed. The task of translating plans from C2 is worsened by the fact that it is usually a high level officer trying to convey a complex plan to a puckster who is usually a young private. That private lacks the military experience to understand the details in the plan at hand while also having to deal with the issues of smoothly going between a printed out C2 plan without latitudinal and longitudinal coordinates to a constructive simulation.

A word of caution: We will never get rid of pucksters entirely, but we can minimize the number of pucksters needed. For the foreseeable future, we will still rely on humans to supervise the automated actions of simulations; however, as pucksters' jobs shift from button-pushing to supervision, they will be able to oversee larger numbers of simulated units.

GAPS FOR SMALL COUNTRIES

There are many gaps between our desired end state and where we are now. We propose they can be bridged with careful development and a willingness to accept simpler solutions than might be proposed for longer-term projects. We have disconnects between key training and operational systems at almost all echelons of the forces. Many other nations have similar disconnects. Even US Army Training and Doctrine Command (TRADOC) is looking to increase the richness of the simulation environment through reuse of operational data. They already have a more robust integration between simulation and C2 than most small nations.

Through the Live, Virtual, Constructive Integrating Architecture (LVC-IA), US Army participants are able to pass information in a closed network between key training systems, some field instrumentation systems, and limited mission command systems (Markowski, 2013). This system still requires onsite support, but is one nation’s concerted effort to address the challenge of helping soldiers to train as they fight. The few gaps noted in pre-fielding assessments are the same ones we are also seeking to bridge. Providing stimulation to tactical units and performing fires missions in an operationally realistic manner is a challenge. While we have a highly tailored tactical system that supports training our tanks (Calvert, 2003), building to a similar multi-year simulation project is not feasible at this time.

There are options beyond building a system of systems to integrate training and operational systems (Galvin, Hieb & Blais, 2005). One NATO recommendation has been a new data standard to bridge the two types areas. Coalition Battle Management Language was first proposed in 2001 by Carey, Kleiner, Hieb & Brown to be used in live and simulation; in the years since, it has been picked up by the NATO Modelling and Simulation Groups on C2 to Simulation Interoperability (MSG-085, MSG-119). Unfortunately, the utility of these standards has waned as parallel standards (e.g. Multilateral Interoperability Programme (MIP) (NATO, 2007), NATO Friendly Force Information (NFFI) (NATO, 2017)**)** have since been proposed and accepted by the larger C2 community. The C2 Community remained focused more on the live environment than the simulations environment. Meanwhile, the Modelling and simulation community has continued with the use of multiple flavors and versions of standards to choose from (e.g., High Level Architecture (HLA), Distributed Interactive Simulation (DIS) (IEEE Standards Association, 2012)).

CONCEPT FOR DATA REUSE

An efficient, effective cost-saving measure would be immediate data reuse. As an example, plans (tactical graphics) made in a C2 system can be reduced down to a series of geographical points in latitude/longitude format (see figure 1). The tactical graphics of plans made in a simulation model also reduce down to a series of geographical points, often in latitude/longitude format (see figure 2). Translating between one and the other is not, at the base of it, complicated – it is a matter of format.

```xml
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<Symbol xsi:type="TacticalGraphic">
  <Location xsi:type="Arrow">
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      </Altitude>
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      <Longitude>8.1263561705793581</Longitude>
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      <Point>
        <Altitude>
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          <Value>0</Value>
        </Altitude>
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          <Value>0</Value>
        </Altitude>
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      </Point>
    </Points>
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  <Report>
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  </Report>
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  </SymbolCode>
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    <SecondLong>8139352529183262910</SecondLong>
  </Id>
</Symbol>
```


Figure 1. Tactical graphic representing an arrow taken from a “plan” generated in a C2 system


```xml
<?xml version="1.0" encoding="iso-8859-1"?>
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  <CacOverlay Name="O-Plan nr. 1">
    <Path></Path>
    <Desc></Desc>
    <Primitives size="1">
      <PolyLine size="6" Color="black" Style="solid" Thickness="2">
        <Coord Lat="55.6036480252269" Lon="8.13511562075193" />
        <Coord Lat="55.5760234564467" Lon="8.12026302803427" />
        <Coord Lat="55.5749773567" Lon="8.1263561706" />
        <Coord Lat="55.5694081474" Lon="8.1189274074" />
        <Coord Lat="55.5763720892133" Lon="8.11823191431696" />
        <Coord Lat="55.575326090189" Lon="8.12432515803665" />
        <Coord Lat="55.6029500465734" Lon="8.13918006088757" />
        <Coord Lat="55.6036480252269" Lon="8.13511562075193" />
      </PolyLine>
      <Symbols></Symbols>
    </Primitives>
  </CacOverlay>
</JcatsCacFile>
```


Figure 2. The tactical graphic from Figure 1, translated into a JCATS Command And Control (CAC) Layer

This conversion can be done programmatically and mathematically, and the result is an elimination of drawing errors between the two systems, lowering the requirement for pucksters. Figure 3 depicts the data in the C2 system, while Figure 4 depicts the same data translated via software to JCATS.

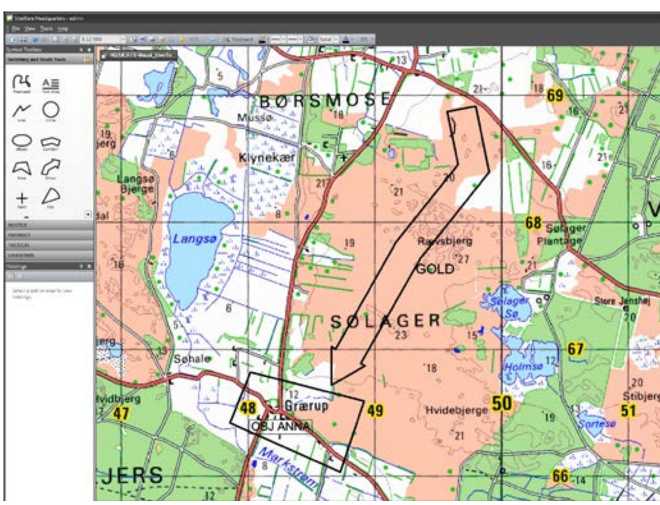

Figure 3. C2 system representation of above data

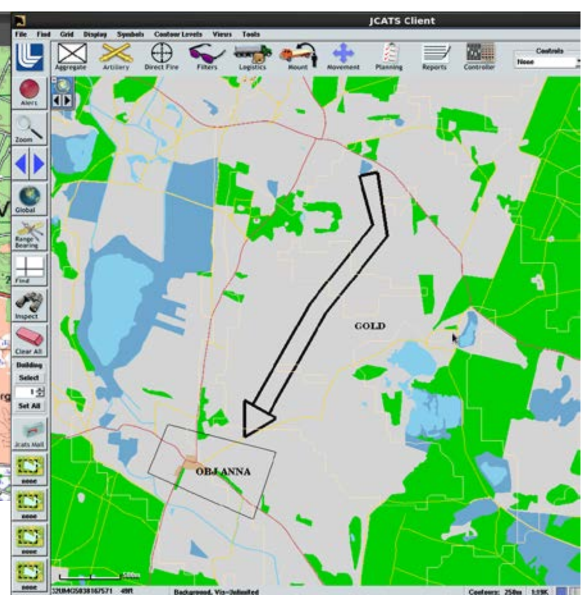

Figure 4. JCATS representation of same.

In the Artillery Observer (AO) training example used earlier, translating an order or request for artillery fire from the live system to a simulation is a matter of maintaining coordinate information while employing the military data standard specific to the AO's system. We currently use voice to transmit this data, taking users away from the system interactions that they use in the field. Distributed Interactive Simulation protocol, also known as DIS, is an easy to use common simulation communications protocol. Any order from the C2 system can easily be translated into an entity state, a fire, or a detonation DIS Protocol Data Unit (PDU) packet using a Live-to-DIS converter. With a simple converter or gateway, we would allow the puckster to use the equipment and software that he would use in the field, then convert his data into the simulation system. Essentially, it would turn him from a puckster to an additional member of the training audience. These kinds of solutions allow all the soldiers in the scenario to train on their real tasks in their real software and systems.

Taking this goal of using operational data a step further, we can actively collect that information and use it in simulations as needed if the data is already generated in a C2 system and consequently transmitted over a network. Often this data is sent unencrypted in text format; this makes it easier for multiple C2 systems from different vendors to understand each other, making them able to represent the same data accurately across a coalition network. The format of this data commonly falls into two groups: a slash-delimited format for military message (ADatP-3) or a XML format that adheres to one of the previously mentioned STANAGs. These easy-to-read formats make conversion simple. Because the data is already flowing on the tactical networks, we can access and utilize the data all the way down to manipulate information on single vehicles, and as we acquire new field instrumentation systems, down to a single soldier.

Reading this data from a network enables us to merge live exercises with virtual and constructive scenarios in a way that is more broadly planned for by projects like the US LVC-IA, even potentially giving a Commanding Officer (CO) of an Infantry Company (INF COY) the ability to see his/her units from an Unmanned Arial System (UAS). If his COY is out in the field doing live training, the CO would have UAS video downlink readily available during deployment, but not in normal day to day training situations. Nonetheless, we can display the situation in a simulated UAS simply by converting real C2 data to DIS if we collate the situational awareness data from his C2 system and allow that CO to have the same capabilities in training that he would expect during actual operations.

To prove this, we have set up a simple NFFI connection from the C2 system to a converter application that translates this standard vehicle and soldier position data to DIS. As shown in figure 5, an NFFI track gives us all the information needed to make a DIS entity state PDU (e.g. what is the unit type, name, affiliation, and position (figure 6)).

Figure 5. Standard NFFI entity track

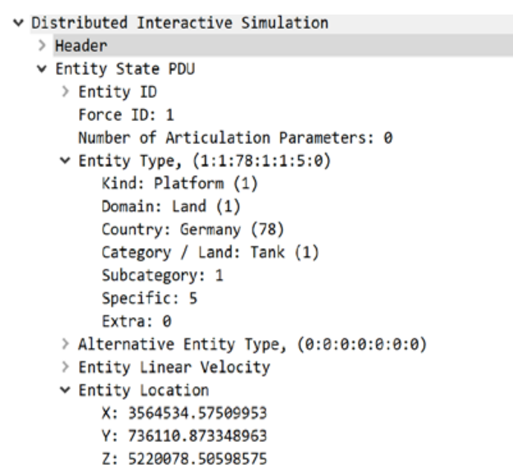

Figure 6. Illustration of the same track in DIS EsPDU

This will give the CO an ability in the training environment that he normally does not have. Let us take this a step further – in a more operational scenario, the units out in the field will be reporting in enemy positions as they see them. The intelligence NCO then has to analyze this data on a very crowded 2D map. Why not give him the same ability to get simulated UAS Video downlink to observe the enemy's reported position?

CASE STUDY

Consider a scenario where we begin to merge live and virtual to get the full potential of this idea. A platoon leader takes his platoon to the field to train standard operating procedures. The platoon moves forward and, at some point, observes an enemy armored personnel carrier 600 meters away. The platoon leader orders the soldier carrying a specialized modern anti-tank weapon to destroy the enemy. Everyone knows a lone infantryman moving to engage an enemy armored vehicle at this range is not the way to handle the situation. The unit would normally observe and call in artillery or tank support. But in this training scenario, they cannot because of the resources required; there are no artillery or tanks supporting the infantry training and consequently, an opportunity to coordinate realistically is missed.

What if, as previously mentioned, the data for both the troops and enemy armored personnel carrier are available in a DIS format and the tank crew is positioned in the simulation center in their tank simulator? Then the platoon leader could call on the appropriate support. In the simulation, the tank crew would be able to see both their own troops and the enemy, making the appropriate maneuvers with the aim to destroy the enemy armored personnel carrier in the simulation. Since the vehicle in simulation has tactical communications onboard, a single message could be used to alert the armored personnel carrier that it has been destroyed, and to set off a smoke marker. This makes the training much more realistic in terms of performing to task standards rather than to resource standards. This could be achieved without the use of pucksters or the requirement to prepare live tanks. The tank platoon resources are not blocked out for an extended amount of time and they are able to perform their normal daily tasks without interruption until they are called to go to the simulation center. The only dimensions missing for this to be a full blown merger into mixed reality are smell, sound and the fact that the infantry platoon will not physically see the tanks, which is a problem that has affected other mixed reality simulation tests (Reitz & Seavey, 2014). Doing this can be easy for countries that have the luxury of procuring expensive simulation equipment and equipping all field units with good solid systems like MILES rather than having to rely on C2 system data. But as mentioned, when the "not so economically privileged" countries procure simulation equipment, it is done piece by piece. The aftermath of this acquisition strategy is that different systems have been bought by different branches. Making all these simulation systems communicate takes time and effort, not to mention money. These are additional resources that were not calculated in the initial bidding process, nor even anticipated. That is why reusing already existing data is an inexpensive, low tech, and effective way of enhancing training. All this is possible utilizing equipment and data already available.

This has been tested in a limited ad hoc scenario during the Bold Quest Coalition Capability Demonstration and Assessment 16.2 (BQ16.2). The Danish Army wanted to participate in BQ16.2 with tactical vehicles, testing elements of the tactical communication network; unfortunately, due to limited funds, it was not feasible to transport these vehicles across the Atlantic. In order to accommodate the Danish BQ16.2 testing objectives without the physical vehicles, we experimented with different virtual and constructive simulation-based setups. Ultimately, we used the set-up pictured in Figure 7.

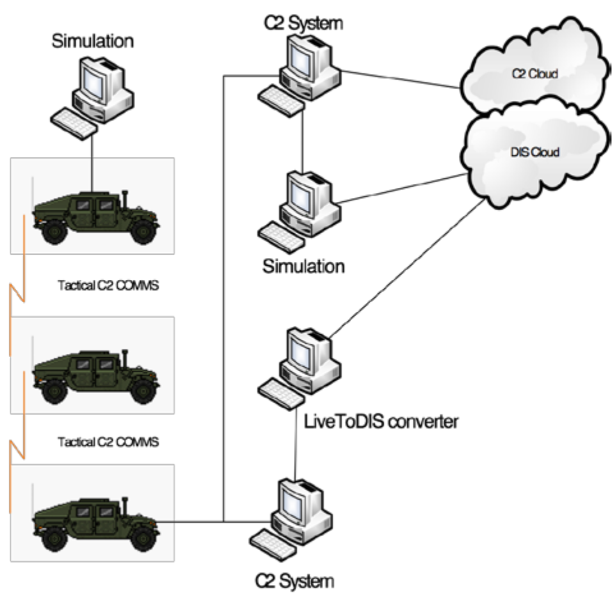

Fig. 7. A test setup using tactical communications as intended and then translating this data to DIS.

Because the actual vehicles remained in Denmark, a single puckster was needed to spoof the live Danish tactical vehicles' GPS tracks to a location in the field that was alongside the rest of the BQ16.2 forces. This was done using the existing on board tactical communications system. The tactical vehicles then believed they were operating in the U.S. and exchanged their internal C2 data as intended using their organic tactical communications system. A Headquarters C2 system pulled the data from the field and sent this data on to a recipient thinking it was sending data to another C2 system using NFFI track messages, all as intended and conceptually realistic.

A LiveToDIS converter picks up those NFFI tracks and translates them into DIS, sending this data into the DIS cloud. From the DIS cloud, the information on the location of the vehicles populated other simulations as well as the C2 systems of coalition partners. Additionally, DIS data from other simulations representing other units in the demonstration was sent to the HQ C2 system and the vehicles.

This test did not show the full potential in the concept due to a number of factors. The vehicles were physically in Denmark; therefore, simulation was needed to convince the vehicles that they were in fact in the U.S. No damage models were implemented at the time of testing, which caused the problem of DIS entities that could not be harmed. Fired at, yes, but they were unable to automatically take damage. Still, as a proof of concept, it is considered a success for integrating real and simulation data. This trial shows that live C2 tracks can be incorporated in the DIS cloud and flow both ways. The user experience of the troops participating in their vehicles back in Denmark was a positive one as it allowed them to train with different forces in a mostly realistic data environment.

This setup was recently repeated in Denmark with success, now without the puckster. The live vehicles were driving in the field close to our simulation center in Oksbøl while graphically represented in various simulation models (Virtual Battle Space 3 (VBS3), and Steel beasts, among others), this time with effects integrated into the system.

RECOMMENDATIONS

1. Integration of C2 systems to Sim should not be achieved by another standard.

Some have suggested that there is a need for another data standard to bridge the gaps between combining the live C2 world with simulation, but small demonstrations have shown this gap is more easily and inexpensively bridgeable by existing standards. Making things "easier" by forcing the development of another standard may actually make things worse. It requires agreement by all participants, extensive initial development and testing, then the development and testing of new interfaces and upgrades to old interfaces that must be compliant with the new standard. Even worse, incorporating a new C2-SIM standard will cost money and time which smaller countries might not want to invest. Defining a new standard would be required if the standards we already have do not support what we want to do. There are standards already being widely used within the respective communities of C2 systems and simulation, and they do support our requirements.

2. Balance fidelity and costs

You will often hear the demand for high fidelity when training soldiers using simulation. High fidelity simulation models are expensive. Looking at some of the examples given, are we sure that we need a 100 percent accurate damage model implemented, or for every bolt on a tank to be accurate to the centimeter?

In the situation above where we have a tank in virtual simulation supporting an infantry platoon, is the aim to find out which precise damage was dealt to the enemy APC or is the aim to train the soldiers in doctrine and standard operating procedures? In Denmark, we aim for the latter. We want the training audience to feel their success when they do things the right way; more to the point, we want to create consequence for poor decision-making.

We want the platoon leader to assess the situation, make his decision, and coordinate with the tankers. We want the tankers to observe where the infantry is, where the enemy is, and make a coordinated attack, preferably without harming their own units. Destroying the enemy APC is not really the primary objective with the training, but correct coordination between units is. In essence, a simple hit or miss calculation will be sufficient.

That said, we realize that the closer you get to the single soldier, higher fidelity is needed. Once we have settled on this fact, things get a lot cheaper. We will always need some of the high fidelity simulation models, we will always need simulation models. But with a little imagination, a good technical staff, and knowledge of code and protocols, countries will be able to make their own inexpensive add-ons to simulation models, enhancing their training with little effort.

3. Innovation requires broad institutional support.

We have the technology on hand to build on the small cases described in this paper, but are struggling to convince people to use it in a broad institutionalized way. We have spent years convincing superiors that simulation is the way forward, and we may finally be winning. Convincing them that we can transport data from simulation to their C2 systems, enhancing their training, is still a struggle. Suggesting that we can go both ways, sim-live-sim-live, is like pointing towards the Holy Grail – it can seem so farfetched that decision makers have a hard time accepting what can be done even when presented with working software examples,.

The fact is that this is technically easy, but convincing our peers and leadership is hard. Technically all that this takes is rudimentary knowledge of programming, a bit of research (or experience) and, of course, time to write and test. As the above has shown, we already have soldiers generating the needed data on a regular basis. Convincing a small army to finance a development process of reusing this data is like trying to do a 180 degree turn with an oil-tanker using a salad leaf for rudder, though – it takes time and effort, and can often be overcome by existing processes and momentum.

What we small armies need is a "leap of faith." We need the commanders to trust that innovation can occur from within their own staffs.

CONCLUSION

To prevent the next Battle of Dybbøl-style outcome, Denmark needs to remain flexible and adaptive to new technologies; in many ways, the resource constraints that impacted our system then can be used to our benefit now. All small nations who lack the large budgets to spend on lavish programs must embrace cost-cutting techniques and the benefits of not being the first adopter of a technology or concept. A simpler model for bridging the gaps between tactical and headquarters C2 systems and virtual and constructive simulation will have durability as technology, military standards, and simulation standards continue to evolve. By keeping our solutions lightweight and practical, we will be able to adapt to the best of new technology and avoid investing too much in supporting technology and concepts that might become obsolete.

Executed successfully and at a larger scale in the future, similar techniques as the convertors and gateways described above, along with expansion of data re-use, will lead to a future where information flows freely between tactical C2 systems and virtual/constructive sim models. This will create better, affordable, solution-focused training that will benefit future soldiers in a practical and measurable way.

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