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NET-CENTRICITY – WHERE IS THE DATA?

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ABSTRACT

The U.S. military has made substantial progress in developing and fielding C4ISR systems that can collect and gather overwhelming amounts of valuable raw sensor data. The problem that comes along with this plethora of data is how can the U.S. military determine what methods are effective to distribute, access, and transform the data into knowledge or actionable information in an environment with transient or low-bandwidth networking. There are so many dynamics that can be manipulated that it is sometimes difficult to determine if a proposed system or approach is solving a problem or simply adding to the problem. This paper will present a simulation architecture that has been developed that allows platform level components to be integrated into an end-to-end operational thread with the ability to collect metrics for the purpose of determining measures of effectiveness.

INTRODUCTION

The evolution of deployed sensors is accelerating with the network connectivity in both urban and battlefield environments. The amount of data that can be collected and provided to decision makers is overwhelming and requires solutions to offload and help the decision makers process the collected data more effectively and efficiently. The real problem is how the military can determine what methods are effective to distribute, access, and transform the collected data into knowledge or information in an environment with transient or low-bandwidth networking. Part of the solution is to develop a simulation and analysis environment where alternatives can quickly be developed and analyzed for effectiveness without having the overhead of building an entire product just to find out it does not address the critical needs in an effective manner.

This modeling and simulation architecture provides a scalable environment to plug and play live or virtual sensors, Command and Control (C2), and communications components into a variety of configurations to quickly develop scenarios for the purpose of determining effectiveness of not only sensor combinations, but vehicle configurations. This architecture offers a low cost solution to measure the system performance of a simulated system through stimulation of the sensors and C2 in an operationally relevant environment, without the expensive cost of deploying and testing large numbers of real systems. The metrics generated can then be analyzed to measure the effectiveness of the system to distribute, access, and transform the data into knowledge or actionable information in an environment with transient or low-bandwidth networking. In addition, this simulation environment provides a structure to rapidly develop concepts of operation threads for the purpose of working with team mates and customers to demonstrate capabilities in an operational setting.

The objective of this paper is to present a simulation architecture environment with the following characteristics and capabilities:

- Scalability – provides an infrastructure to simulate individual sensors in a variety of operational environments to a mix of integrated sensors on multiple platforms in a variety of operational environments.
- Usability – provides an environment for first person interaction with the various systems to determine ease of use characteristics without having to build the actual system.
- Effectiveness – provides a set of metrics that can be collected to determine whether the added capabilities and systems are more effective than existing equipment.
- Training – provides the infrastructure and environment to train on the new equipment in virtual, yet realistic environments that can be

much cheaper than training in live operational scenarios.

This simulation architecture provides a set of metrics that can be collected during operational scenarios to help determine the effectiveness of the new equipment and capabilities, but it also provides data that can be used for training to increase the readiness of the troops to effectively deploy the new capabilities and equipment and determine areas where additional training is needed. Raytheon has been developing and working with this type of architecture for the past three years.

THE NEED

Today's network-centric military relies heavily on a mix of sensors for gathering a plethora of data to be distributed over mobile ad-hoc networks. Net-centricity is a force multiplier that relies on adaptive communication technologies and dynamic network quality of service (QoS) to enable mission-critical applications and the transformation of raw sensor and intelligence data into actionable knowledge.

Additionally, modern-day combat decision making depends on information flow. Combat networks need to collect and disseminate data that is subject to delays. These delays are unequal depending on routing protocols, terrain, environmental effects, connectivity, hops, priorities, available bandwidth and traffic. The perceived truth of the state of a network can significantly lag the truth on the ground. In addition, the interpretation and correlation of the data becomes an overwhelming task without the aid of automated fusion and correlation techniques.

In order to build next-generation data collection, data fusion, and communication systems, system developers need to accurately predict end-to-end performance. But while traditional network simulations assumed near-perfect communications, they don't reflect the reality of the battlefield. Nor do they predict whether the information on the network will be useful for the decision maker.

Building the actual equipment to test the overall effectiveness in a variety of realistic operational scenarios quickly becomes a costly and nearly impossible task. Network and equipment tests could require months to build a small sample of the equipment to test in a single operational environment, and then finding the location to perform the test can become difficult and costly. The results of this type of testing end up not reflecting the true operational setting and tend to render limited results. Rather than providing results in terms of delay or packet delivery rate, simulations are most valuable when they can test protocol and device impact on end-to-end performance.

Because so many factors go into determining network performance, the simulation of such systems is computationally very demanding. To be an expert on next-generation sensor capabilities and wireless networking requires a complex set of expertise. This includes an understanding of sensor phenomenology and mobile communication, quality of service, software defined radios and the network-centric services that support them. Most current simulations do not handle all of these factors or provide results at the wrong level of fidelity.

THE SOLUTION

With the evolution of simulation efficiencies, network and equipment tests that traditionally required months to perform can now be performed in minutes using with real-time speed and real-network behavior. The technology for virtual environments and interaction between the virtual entities and live entities has evolved to a point where it is feasible and practical to use a simulated environment for not only operations analysis, but for live training. For example, a capability like VIRTSIM™ allows you to take the metrics collection down to the tactical edge, the warfighter, to assess human factors such as fatigue and human response timeliness and/or accuracy when using one candidate system versus an alternative. VIRTSIM™ provides one the most advanced physical assessment tools and databases to evaluate athletic and industrial movements and mine information about trends and cross training population performance. This tool has been outfitted with real-time display of body angles, footprints, dynamic flexibility, center-of-gravity, and almost any other type of data related to physical performance required.

Key enablers of traditional off-the-shelf network simulators have been open standards such as Distributed Interactive Simulation (DIS) and High Level Architecture (HLA). Adopting and leveraging these standards has led to the ability to more rapidly integrate different simulations together to support multiple operational scenarios. As no one tool can model all potential capabilities, these standards ensure interoperability among all of the simulators and allow the best simulator to be used to match the capability model need. By using the strength of each simulator and leveraging these standards, a seamless, scalable, and usable architecture can be created where metrics can easily be collected.

In addition to having open standards, the simulation tools must be extensible to ensure the applications and capabilities being tested can be incorporated into the simulation. For example, Virtual Battlespace 2 (VBS2) is a fully interactive first person virtual environment that is highly customizable and can be extended to create accurate realistic virtual prototypes of systems. Through the use of plug-ins and scripting links, interactions can now be created between live and virtual systems (e.g., Command and Control (C2) systems, data fusion algorithms, crew stations, live sensors and systems, etc.).

The development of the prototype systems helps to mitigate risk and ensure results are beneficial to the end-user. This architecture provides a first person interaction with the prototype systems in an operational environment and allows end-to-end performance to effectively be tested through the collection of metrics without spending money to build the actual system. Key areas of concern include understanding the operational effectiveness of proposed capabilities, Human Machine Interface (HMI) design and their impact on operator immersion, impacts (positive or negative) on Op Tempo, Tactics, Techniques and Procedures (TTP), networks and communications.

This architecture not only allows for the visualization and interaction directly with prototype systems but also provides program management with a powerful, virtual platform to test out new capabilities and pre-planned product improvements (P3I). With this architecture, innovations and ideas can be turned into a virtual system that users can interact with first-hand and even “fight” anywhere in the world against any potential threat thereby helping to shape and develop requirements. Additionally, these virtual platforms allow verification and validation of prototype systems by allowing virtual systems to interact with production systems.

SIMULATION ENVIRONMENT

Understanding Operational Effectiveness. The main objective of using a simulated environment is to provide quantifiable measures that determine success or need for course correction. In order to accomplish this, valid experiments must be developed that will reflect the mission environments of the fielded systems. Force-on-force entity generator (OneSAF, VR Forces, etc.) are used to provide the scaling needed to complement the live and virtual systems. Fully interactive 3D synthetic environment, such as VBS2, suitable for a wide range of purposes are also used. Government vetted scenarios must be leveraged to ensure the experiments would be relevant to today’s fighting force.

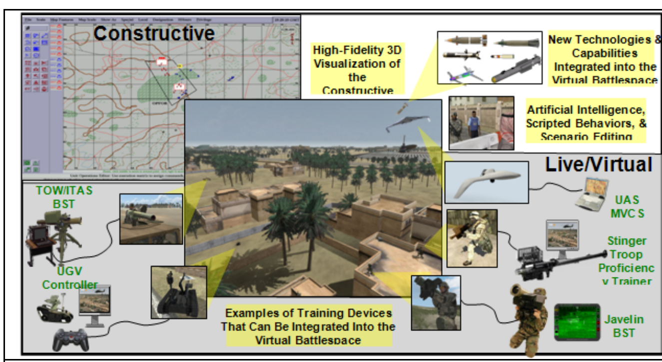
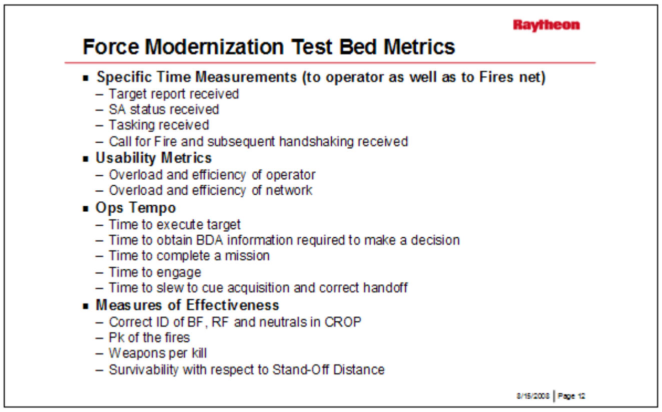


Figure 1: Simulated Environments

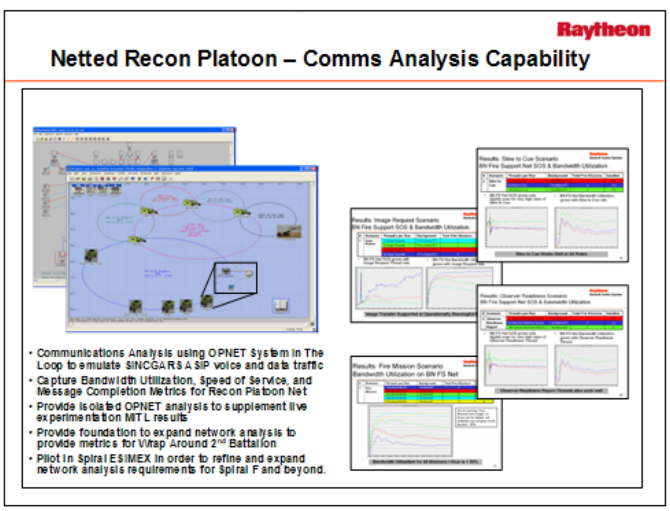
Live-Virtual Environment. As illustrated in Figure 1, the modeling and simulation architecture uses a combination of live and virtual systems within a simulated environment to experiment with new capabilities to evaluate the mission effectiveness of those capabilities. Live systems have included: AFATDS, SINCGARS, EPLRS, LRAS3, ITAS, Javelin-CLU, and the Ground Control Station (MVCS) for UAVS. Virtual systems in VBS2 have included: LRAS3, Javelin-CLU, ITAS, mast mounted sensors, and radars along with some notional systems, leveraging the power of virtual model development. Figure 2 illustrates some of the platforms and sensor systems simulated within VBS2. VIRTSIM™ provides the most realistic immersive environment in the market today and one the most advanced physical assessment tools and databases to evaluate athletic and industrial movements and mine information about trends and cross training population performance.

Figure 2: Simulated Sensors and Platforms

Measures of Mission Effectiveness. The initial architecture has been focused on Current Force Soldiers at the tactical edge (brigade and below) and the impact of increased networked capabilities. It is important to understand the limitations of the architecture and the type of evaluations that can be conducted and in-turn, the Measures of Effectiveness and the Measures of Performance that can be collected. The measures vary based on capability evaluated and mission type. Once the measures are identified, logging mechanisms are developed along with data recovery tools to perform after action reviews. The table below provides a representation of typical measures. VIRTSIM™ allows you to take the metrics collection down to the tactical edge, the warfighter, to assess human factors such as fatigue and human response timeliness and/or accuracy when using one candidate system versus an alternative.



Network Analysis. By using a combination of live and virtual systems and ensuring that message passing can occur between the two types of systems, testing communication and network constraints could occur and thus be able to measure current and future force radio bandwidth constraints at the tactical edge. Using VBS2 plug-ins, Joint Variable Message Format (JVMF) messages are able to be translated between the live systems and the simulation protocols of the virtual systems. The size of the messages equivalent to the messages sizes that would be passed between fielded live systems is kept intact to properly evaluate bandwidth utilization, speed of service, and message completion metrics for the lower tactical internet.



Human Machine Interface (HMI) Design and Training. To provide the warfighters at the tactical edge, the enhanced situational understanding that comes from new network technologies, modifications to the existing HMI are usually needed. The simulation architecture provides the proving ground for placement of new data and symbols with minimal impact to the user. Figure 3 provides an illustration of the type of HMI presentation that is typical for the sensor systems simulated in VBS2. Operator efficiency and immersion can be evaluated to ensure the warfighter can keep his “head in the fight”. This also provides the infrastructure and environment to train on the new equipment in virtual, yet realistic environments that can be much cheaper than training in live operational scenarios.

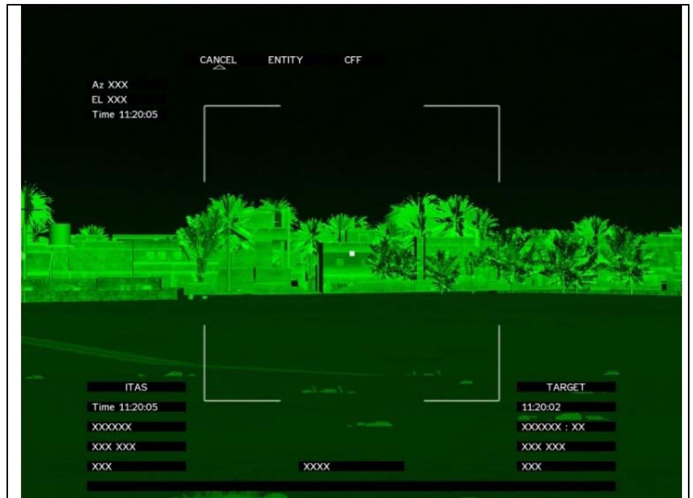


Figure 3: Example HMI

CONCLUSION

A plug and play simulation architecture for existing and future Army platforms has been presented in this paper. It achieves the objectives of scalability, effectiveness, and usability while providing operationally relevant environments to support training and metrics collection. The core simulation architecture is comprised of an extensible 3D synthetic environment and a force-on-force entity generator able to communicate through open standards that provide the framework to effectively and efficiently configure new sensor suites on different vehicle and stationary platforms to support a variety of operational missions. This simulation environment provides the means to collect metrics to determine both the measures of effectiveness of the conceptual equipment along with the readiness of troops to use the equipment in different engagements. The final and perhaps most important benefit of this simulation architecture is, it will accommodate legacy systems as well as the current and future generation capabilities. The following table captures some of the architecture capabilities embodied in the simulation architecture and the associated benefits.

Architecture Capability	Benefit
Experiment with TTPs and Doctrine	Optimize and Validate Concept of Employment
Investigate HMI Design	Investigate Operator Efficiency and Immersion
Stimulate C2 Across Multiple Echelons	Validate System Requirements, Interoperability, Data Overload vs. Actionable Information
Test Communication and Network Constraints	Validate current and future force radio bandwidth constraints at the tactical edge
Demonstrate Operational Thread	Customer Alignment