Using Reconfiguration To Provide Efficient Use Of Resources

David Uhlar
Lockheed Martin Information System
Orlando, Florida

ABSTRACT

The Close Combat Tactical Trainer (CCTT) is a simulation system wherein various elements replicating actual combat vehicle weapon systems along with command and control elements are networked together providing real-time, fully interactive collective task training in a virtual environment. The M1 Variant [M1 (V)] design was conceived to provide improved efficiency and a reduction in resources required in supporting the Army's training needs. The CCTT M1 design consists of a Crew compartment; containing the Commander, Gunner, and Loader stations; a separate Driver compartment and three electronic racks. Each original M1 Simulator requires 224 square feet of floor space and supports only one configuration of an Abrams Tank.

The newly designed M1 (V) simulator is designed to make better utilization of assets within a training site by using kits. These kits support the use of multiple configurations within one unit. Currently, four kit configurations have been designed: the Abrams M1A1, the M1A1-Digital (D), the M1A2, and the M1A2 System Enhancement Program (SEP). The number of different types of kits is expandable to as many Abrams configurations as needed. This is accomplished through the use of a base or common simulator unit design, to which reconfiguration kits are added to customize the trainer to the unique requirement. Each kit is stored in standard supply cabinets, requiring less than 5% of the unit space.

Additionally, the reconfiguration ability of the M1 (V) allows for the rapid development of new configurations to support concept development and analysis of changes to the tactical vehicle. Design changes can be incorporated into the trainer and vehicle simultaneously. This allows the simulator to be used to train the soldiers required to support tactical evaluation milestones.

In designing the M1(V), the original four stand-a-lone M1 simulator designs were analyzed for commonality and to identify areas for design improvement. This paper discusses the analysis and development work to improve Usability, Maintainability and Life Cycle Cost of the CCTT Abrams simulator for the Army.

ABOUT THE AUTHOR

David Uhlar is currently the Systems / Hardware Lead for the Close Combat Tactical Trainer program at Lockheed Martin Information Systems in Orlando, Florida. He has seven years experience in the development of high fidelity simulators. His prior experience is 11 years in providing supportable designs for various signal processors and sonar systems at International Business Machines in Manassas, Virginia. He has a BSOE ('80) and MSOE ('82) from Florida Atlantic University.

Using Reconfiguration To Provide Efficient Use Of Resources

David Uhlar
Lockheed Martin Information System
Orlando, Florida

INTRODUCTION

What is the key to readiness? The answer is Training, Training, and more Training. Without the continuous exercise of the mind and body the skill or proficiency fades with time. Simulation provides the tools to keep those skills honed. The armed services are faced with a dilemma as more weapon system configurations are fielded. Should they build more trainer types, requiring more facilities to house them, or do they spend more on development of flexible systems? Reconfiguration is the key to providing those tools in the most efficient manner possible.

Background

Close Combat Tactical Trainer (CCTT) was developed in the early 90's to provide high fidelity simulation of several armored vehicle types to support the Army's training needs. Over the years, through various Engineering Change Proposals (ECPs), the number of unique simulator configurations continued to expand. This expansion was driven by the planned upgrades to the tactical vehicles and the Army's need to keep the training simulators compatible. This paper focuses only on one of those simulator types, the M1 Abrams Tank (Figure 1).

Figure 1. M1(V) in M1A1 configuration

The CCTT M1 design consists of a Crew compartment; containing the Commander, Gunner, and Loader stations; a popped hatch display assembly, providing vision block views and open hatch views; a separate Driver compartment; and three electronic racks (Figure 2).

Figure 2. CCTT M1(V) Enclosures

These major sub-assemblies are housed in both fixed sites and mobile (trailer) environments. The simulator configurations involved in the effort were the M1A1, the M1A1-Digital (D), the M1A2 and the M1A2 System Enhancement Program (SEP). The M1A1 and M1A2 are two of the original CCTT configurations.

Although commonality was considered during the initial development effort, the emphases for hardware were on fidelity and cost, not on reconfiguration. This resulted in several trainer types, built from common, or like, components. As the years progressed additional configurations were required. Retrofit kits were developed to modify the existing CCTT simulators to the new configurations. Each modified simulator still only supported one configuration. This resulted in the Army requiring the relocation of simulators to different sites to support the changing training needs and Army organizational realignments.

The initial goals for the M1(V) were 1) to improve the availability of each unit configuration as the training mission of each site changed, 2) Reduce the maintenance costs for new M1 configurations, and 3) Reduce the Life Cycle Cost to the government.

ANALYSIS

The CCTT M1 (Abrams) family of simulators was reviewed to identify areas of commonality and areas for potential design improvement. Additionally, different levels of commonality were identified, those common to all configurations (core), those common to A1 configurations and those common to A2 configurations.

All remaining items were unique to one of the four configurations. Once each item was allocated to a particular group they were analyzed for the best way to support reconfiguration. During the M1 (V) development effort, items were moved to a different level as the benefit to the trainer's flexibility was identified.

The number one driving factor required prior to assessing designs is the answer to the question "How often will the trainer be reconfigured"? This is the most important question because design considerations change, as the time between reconfigurations increases. The trainer that will be reconfigured daily has more requirements for quick disconnect fasteners than the trainer that will be reconfigured only once a year. Also, the ruggedness of the assemblies must be assessed so as to not introduce additional failures due to reconfiguration handling.

The time required to reconfigure must be treated as a performance measurement throughout the design phases. Time budgets must be allocated and estimates updated as the design progresses. For the M1 (V) reconfiguration estimates were established early, updated with each design change and presented at Preliminary Design Review (PDR) and Critical Design Review (CDR). The first trainer manufactured was used to demonstrate and validate the reconfiguration estimates. The results of the demonstration were very positive. They proved that the M1 (V) trainer could be reconfigured in approximately four hours.

The M1 (V) design was based on being reconfigured at least once per month. This required design improvements in:

- Attaching hardware
- Connector reliability

All assemblies subject to removal, during reconfiguration, were modified to include captive attaching hardware. This improved not only the time required to reconfigure each trainer, but improved maintainability by not having large quantities of loose hardware to keep track of. In the original design, some of the connectors used were lower cost, low number of mating cycle connectors. All areas that were affected by reconfiguration were reviewed for connector reliability and modified to use connectors designed for a minimum of 500 mating cycles.

During the design efforts for reconfiguration, other areas were analyzed for potential savings. The savings were in terms of time, manpower and ultimately life cycle cost.

Enhancements

Maintainability became the driving factor for identifying areas for improvement. Input from the field maintenance team, the manufacturing assembly team, Quality and previous development efforts were analyzed to identify candidates. These "lessons learned" were also used to provide guidance to the designers. The following areas were identified for potential enhancements:

- Addition of connectors to the system cable
- Electronic rack access
- Maintainability of the cupola (hatch)
- Addition of protective covers
- Relocation of a panel susceptible to damage
- Revision of assembly methods

The main system cable had been designed with a minimal number of connectors to reduce cost. This area was reevaluated and connectors installed at realistic break points in the wiring. Comparing Figure 3 to Figure 4 illustrates the area of improvement. Connector panels were added at the equipment racks (Figure 4), the crew compartment and the driver compartment. This improvement now aids in the transportation and installation of the trainer . Adding connectors made the trainer much more modular, thus easier to move.

Figure 3. M1A1 System Cable

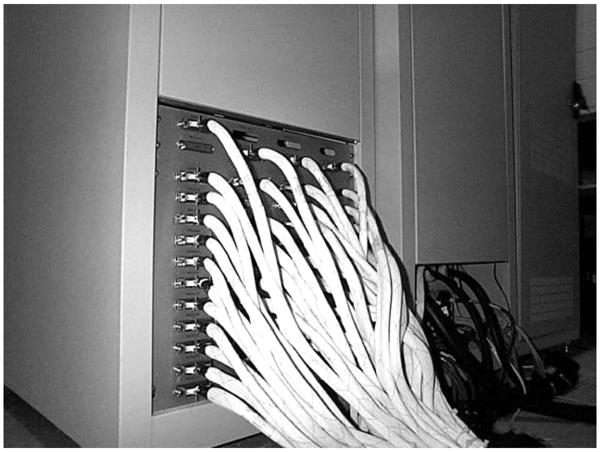

Figure 4. M1(V) Equipment Rack I/O panel

The electronic rack access was improved by relocating several of the internal devices. The mounting plate shown (Figure 5) completely blocked access to the top circuit card cages, and hindered the access to the bottom cage.

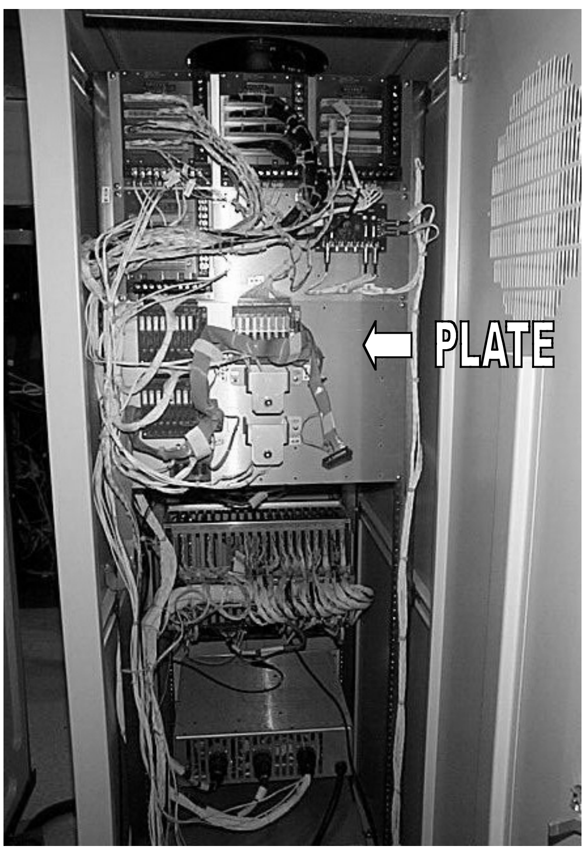

Figure 5. M1A1 Equipment Rack Rear View

All items on the mounting plate were moved to the internal walls of the equipment cabinet. This dramatically increased the access to the Programmable Interface Electronic (PIE) cages (Figure 6). Mounting to the rack side is an area that is typically overlooked by the designers. Because it's a standard rack, items should only be mounted to the standard rails.

Figure 6. M1(V) Equipment Rack Rear View

The area that required the most work was the cupola. In the A1 configurations the cupola rotates (see Figure 7) and in the A2 configurations it is stationary. Also, the visions blocks are different in size, quantity, and configuration. The existing design mounted the cupola from the top of the crew station. The cupola is located under the popped hatch display assembly. Since this assembly weighs in excess of 3000 pounds, it is not something considered movable for reconfiguration. Thus, the entire cupola area required redesign to make it removable from inside the trainer. In the process of redesigning the cupola area, several maintainability issues were eliminated. The old design required a complex adjustment procedure for the drive belts and constant adjustments to the belt alignment. The M1 (V) does not require adjustments or alignments to be performed.

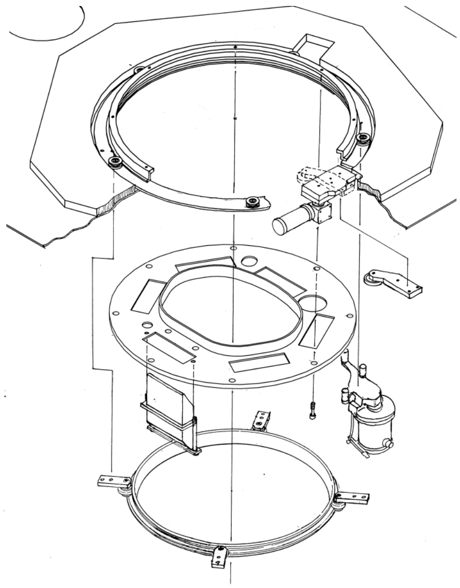

Figure 7. M1(V) A1 Cupola Exploded View

A simple cover, based on a field implementation, was added to the base design to protect a sensor connector that was subjected to damage by the trainee during normal use. Similarly, a trainer unique panel was relocated to protect it during the trainee ingress and egress.

Assembly methods, like cable routing, were revised to reduce the chance of damage during use or maintenance of the trainer. Also, the assembly methods required change due to reconfiguration needs. Cable ties needed to be placed so as to not interfere with removal.

The resulting configurations developed consisted of a core module, which contains all items common to every configuration and six kits. The core accounts for the majority of the module. To customize the generic core module, kits are added. Currently, six kits have been developed to support the four unit configurations required for the Abrams simulator (Table 1). In order to obtain an A1-D configuration the A1 common kit is installed in the core, then the A1-D unique kit is installed to complete the configuration.

KIT	A1	A1-D	A2	A2-SEP
M1 (V) CORE	Base	Base	Base	Base
A1 Common	Added	Added		
A1 Unique	Added			
A1-D Unique		Added		
A2 Common			Added	Added
A2 Unique			Added	
A2-SEP Unique				Added

Table 1. CCTT Kits

Goals Realized

The newly designed M1 (V) supports the use of multiple configurations within one unit; thus, greater flexibility of assets was realized. The Army can position kits to best support the training requirements. Changes in training needs or Army organizational changes can be addressed with the movement of kits, not entire simulators. Each trainer movement requires approximately $30,000 verses the $300 to $600 a kit requires.

The improvements to the maintainability of the system will aide in the reduction of maintenance cost of the trainer. Better access was provided, and improved designs with less moving parts simplify repair actions. Complex adjustment procedures were eliminated. Areas subject to damage by the trainee were reduced resulting in reduced replacement costs.

Reducing the numbers of individual simulators required to support the Army's needs lowered Life Cycle Cost (LCC). The Army no longer needs four different individual trainers. The M1 (V) with kits can be obtained for 40 percent less than the individual unique trainers. Also, this leads to an overall reduction of facilities, personnel, and resources like spares required in supporting the common module.

A reduction in the facility requirements is realized with a reduction in space required to house the simulators needed to support increasing training needs. Each CCTT simulator requires approximately 224 square feet of floor space to support only one configuration. The M1V still requires 235 square feet, but now supports four configurations. This is a net reduction of 381 percent. Facility requirements can now be driven by the number of student hours available, not the size of the trainer. Another way to look at it is that the Army can now virtually place four times the number of M1 trainers in the current building allocations.

It does not stop there, as the need for new configurations is identified, they can be added with little impact to facility requirements. The discussion of space is not intended to place less emphasis on other facility demands, like power, and networks.

The number of unique trainers at each site reduces the demands for both. This also drives the number of unique spares required to support the trainers.

Reconfiguration of the M1V requires approximately four hours for each module. This minimal time aides the ability of the training site to support the ever-changing training demands. Demand peaks can be reduced, if not eliminated, through simulator reconfiguration. A site can be one configuration one day and a new configuration the next.

Additional Benefits

In addition, reconfiguration aids in the rapid development of new configurations to support concept development and the analysis of changes to the tactical vehicle. Instead of being behind vehicle product improvements, the simulators are being updated concurrently with the tactical vehicles. This increases the use of the simulator to train crews that will support the tactical evaluation milestones.

CONCLUSIONS

Design for reconfiguration from the start. Taking this into consideration up front provides a benefit to manufacturing, maintenance and life cycle support. In the case of the CCTT M1 (V) program, the configurations were defined during other efforts. Thus, there was a basis for identifying the configurations that would be considered. In other efforts, all configurations may not be known up front. But every vehicle type is subject to improvements over time. So, both the designer and customer should consider possible future upgrades by implementing the maximum modularity of design. With a modular approach, the effect of any future or unanticipated configurations can be minimized.

Get the question “How often will the trainer be reconfigured” answered early. Without this critical piece of information, the design team will just spin their wheels. Also, if the answer to this question changes late in the design effort, major impacts to schedule and cost will be incurred as the technical solutions are revised.