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USE OF CREW AUGMENTATION TECHNIQUES TO REDUCE COMBAT CREW SIZE

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ABSTRACT

TARDEC is leading the Next Generation Combat Vehicle – Mission Enabler Technology Demonstrator (NGCV MET-D) program, which has developed and implemented new technologies to enhance and augment Crew and vehicle capabilities. As part of this, a concerted effort is being made to optimally interface the crew-member to the technology in a way that will maximize overall effectiveness. The payoff for these efforts will be to have the crew do more than they have in the past, or have a reduced size crew perform at the same – or higher – level as the original crew would have. This study provides a framework process and techniques for crew augmentation with the end goal to reduce combat crew task load and increase overall crew performance.

INTRODUCTION

The Army's efforts toward the study and feasibility of reduced crew vehicle operations stretches back several decades. The argument of feasibility centers on the idea of crew member task load. Task load considerations are the leading concern when discussing reducing the crew size from current crew configurations. It is vital that a reduction in crew responsiveness and vehicle performance during combat operations, specifically during "high stress" situations, does not occur. A reduction of these key aspects would offset any potential increase in capability the reduced crew concept may offer. The Army has recognized that in order for the reduced crewmember concept to work, technology must augment crewmembers to perform all traditional crew functions in order to compensate for the reduction of the crew.

The US Army Tank Automotive Research, Development and Engineering Center (TARDEC) developed and integrated a fully functional two person crew-station to operate a modified Bradley Fighting Vehicle (traditionally operated by three persons). This paper describes the processes and techniques used to develop an effective two person crew-station, including Mission Engineering; Crew Augmentation & Design; and Development and Testing as shown in Figure 1.

Previous Studies & Results

Previous studies, such as those conducted by the Army Research Laboratory (ARL), investigated reduced crew size in support of the Future Combat System (FCS). Utilizing an IMPRINT based model of crew tasks [1], ARL tested the ability of the crew to conduct crew operations with two versus three

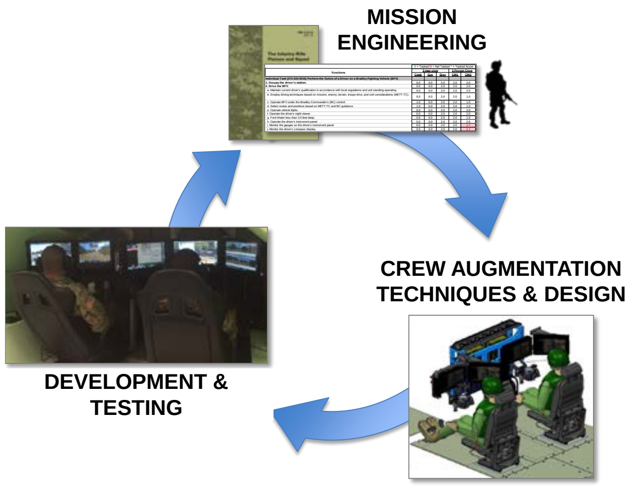

Figure 1: TARDEC MET-D Project Two Person Crew Development Process Overview

crew members. The focus of the study was actual ~~or~~ vs perceived cognitive load on the crew, as it attempted to divide existing crew tasks across two rather than three crewmembers. The experiment concluded that without crew augmentation technologies the crew member performing two sets of tasks (separate and distinct) quickly became overloaded. Also, given the current task load required to operate the vehicle (M2 Bradley) in the stated test conditions; three vs two crewmembers would be more effective. The study did offer insight into possibly distributing the driver functions between commander and gunner functions, aided by automated scanning capability, could be the most functional.

Another study, perhaps the most notable, was part of the Future Fighting Vehicle (FFV) Phase IIIB Experiment. The Maneuver Battle LAB (MBL) tested two person crew using Close Combat Tactical Trainer (CCTT) simulator designed to replicate a three crewmember M2A3 Bradley Fighting Vehicle (BFV). In this virtual environment, the crews conducted offensive and defensive missions during major combat operations in a tactical scenario at the National Training Center (NTC). The study did provide some valuable ~~suggestive~~ insights to help alleviate command and control issues such as crew station redesign.

Although the MBL study was the most comprehensive study prior to the MET-D Program, it fell short in several key areas. First, with respect to the AC3 construct (M2A3 Bradley with 2 person crew), the gunner, whom would normally be located in the turret, was removed from the crew station. The physical design of the M2A3 does not support this as it created both physical and functional challenges in crew operations (Figure 2). This concept placed most, if not all, of the responsibilities of the Gunner and the Vehicle Commander on a single crewmember who is also located in the turret. This arrangement, as discovered in the ARL FCS study, lead to a marked decrease in the effectiveness of the crew's ability to effectively communicate and coordinate during combat operations, especially during "high stress" engagements.

Both studies concluded that a two person crew station cannot function in the same physical space of a three person crew station, especially in existing combat vehicles. Also, an increase in technological capability that could augment the crew during all conditions during combat operations, such as autonomous engagement systems, autonomous driving, augmented reality, and artificial intelligence would reduce crew task load to more manageable levels. Additionally, the vehicles themselves will need to network at some level to pass targets and other mission critical information between systems in order to truly optimize platforms in the future operating environment. Finally, the experiment recognized that the current crew rank and experience level would need to be reexamined from the current BFV crew.

MISSION ENGINEERING

A robust mission engineering effort was performed in order to determine which individual/crew tasks to reallocate and/or augment. This effort required analysis of individual and crew tasks based on selected operational parameters, determined whether to augment or reallocate tasks based on cognitive load reduction, defined operational scenarios to test early prototypes in a virtual environment, and ~~then~~ support integration efforts onto platform.

Initial operational analysis derived from current Army doctrinal individual/crew/collective tasks which were based on the Bradley platform in the form of Task & Evaluation Outlines (T&EO) from a Mission Essential Tasks List (METL). This method formulated the bases which standardized orders of operations at the individual and crew level which were then fully decomposed (Table 1).

Three Vs. Two Person Crew Concept

The Two Person Crew (2PC) concept derives from the M2 Bradley's three men crew individual and crew tasks. The current M2 Bradley crew consist of a Vehicle Commander (VC), Gunner (GNR), and Driver (DVR). Under the two person crew concept, the vehicle crew consist of two crewmembers, Crew Member 1 and Crew Member 2, both with user tailorable but identical crew stations capable of performing traditional vehicle commander, gunner, and driver functions simultaneously and independently – augmented by advanced technologies, specifically autonomous and artificial intelligent systems.

Crew Member 1 (CM1) and Crew Member 2 (CM2) sit in close proximity. Through operational analysis, it was determine that "side by side" collocated crew stations are optimal on the basis of crew coordination, specifically during "high stress" engagement scenarios. One crewmember is designated vehicle commander and therefore senior in ranking to the other. Both crewmembers would be highly trained in the concept, capable of operating the vehicle independent of the other crewmember.

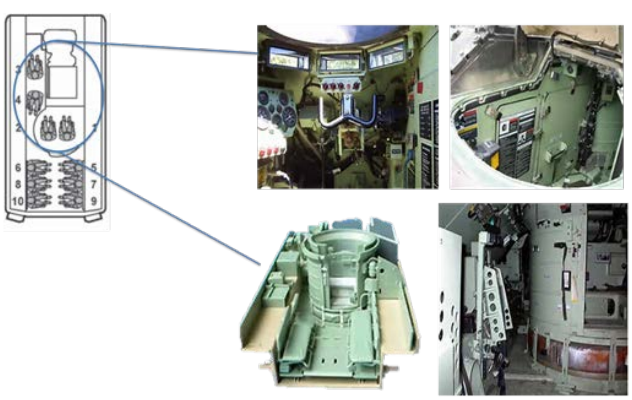

Figure 2: Bradley Crew-station Configuration for Driver (DVR), Gunner (GNR), and Vehicle Commander (VC)

Driving Role – Ideally, while both Crew members would be capable of performing driving functions during all stages of vehicle operations, one crewmember has primary responsibility for driving functions at a given time. Transferring driving functionality from one crewmember to the other is seamless. Augmented by autonomous technology, this function's cognitive load is reduced in order to enhance crew operations during certain stages of operations.

Gunner Role – Both Crew members are capable of performing traditional gunnery functions. Weapon system control is arbitrated such that either

Table 1: Excerpt from MET-D Bradley Crew Operation Doctrinal Task Analysis

Type (Role)	Task
Individual (DVR)	071-024-0016: Perform the Duties of a Driver on a BFV
Individual (DVR)	071-324-6001: Drive a BFV
Individual (GNR)	071-314-0012: Fire the 25-mm Gun on a BFV
Individual (GNR)	071-024-0017: Perform the Duties of a Gunner on a BFV
Individual (VC)	071-024-0018: Perform the Duties of a Bradley Commander (BC)
Individual (VC)	071-001-0008: Detect Targets using BFV Sighting Systems
Individual (GNR)	071-001-0006: Engage Targets using the Weapon Systems on a BFV
Individual (VC/GNR)	171-132-1015: Direct Engagements from the Commander's Position on a BFV
Collective (VC/GNR)	17-5-5424: Engage Targets with the 25mm Gun on a BFV
Individual (VC/GNR)	171-300-0048: Apply the Detect, Identify, Decide, Engage, and Assess (DIDEA) Process

Crew Member is capable of identifying, deciding, engaging, reengaging, and subsequently ceasing-fire during the engagement process. Crew tasks associated with this traditional function are reduced through rationalization of the engagement process – Detect, Identify, Decide, Engage, and Assess (DIDEA). Artificial intelligence along with other autonomous systems capable of tracking and targeting hostile targets quickly and accurately increases lethality and survivability of 2PC operations. Streamlining this function with auto loader technology, advance target detection and targeting systems and overall reliable weapon systems increases the operational feasibility of 2PC operations.

Mission Command/Vehicle Commander - Command of the vehicle is operationally fixed in the sense that only one person can be in command of the vehicle (i.e., the VC); however, control functions should be fluid such that the VC may operate from either crew-station. The VC, with rank and experience commensurate with the position relative to the Platoon organization, will command the vehicle and control in cooperation with the other crewmember. Traditionally, the VC primary duties include directing the driver (driver commands), detecting targets using Commanders Independent Viewer (CIV) or Integrated Battle Acquisition Sight (IBAS), identifying, deciding, and issuing fire commands during the engagement process.

TARDEC Mission Engineering coordinated with several Master Gunners from the Maneuver Center of Excellence to solicit insights on the “ideal” distribution of tasks for a two person crew given their own experiences, participation, and assumptions. Based on discussion, surveys, and observation data collected from participants, and collective analysis the results are is as follows:

CM1 (left seat) - designated primary driver and assistant gunner. Autonomy systems "could" augment some driving tasks but is highly mission and situation dependent. Participants stated that having autonomous systems that are capable of detecting and identifying threats past crew’s ability to optically detect targets would provide an advantage.

CM2 (right seat) - designated primary gunner and minimally assist driver (mostly in degraded situations and negligible under normal operation with 360 degree situational awareness and other systems).

Mission Command (Vehicle Commander) tasks were mostly split between both crew members. Essentially, either crew member (slightly towards CM2) could fill the VC role during most operations. It is more of a matter of "who" is authorized to give weapons release, direction of travel, reporting, etc. - not necessarily the one performing the actual tasks i.e. "pushing the button". This further builds the case for a "profile" type set up where crewmembers decide what functions works best for their individual crew dynamics on a given mission. These functions and sub-functions could be fully decomposed based on the information using the M2 Bradley as a baseline and current NGCV-METD vehicles.

CREW AUGMENTATION TECHNIQUES & DESIGN APPROACH

The MET-D project performed systems engineering analysis to decompose functional means to augment performance of the two person crew. This analysis was based on literature research, TARDEC Subject Matter Expert (SME) experience, and Soldier feedback from early prototyping and testing. This decomposition identified two primary approaches: 1) manage “System Factors” associated with the crew-station and vehicle platform and/or 2) manage “User Factors” associated to the crew persons themselves. These factors are further decomposed into lower level functions as shown in Figure 3 [4-5], which the MET-D Project used to synthesize candidate crew augmentation solutions described in the following subsections herein. The resulting crew-station design physical layout is shown Figure 4.

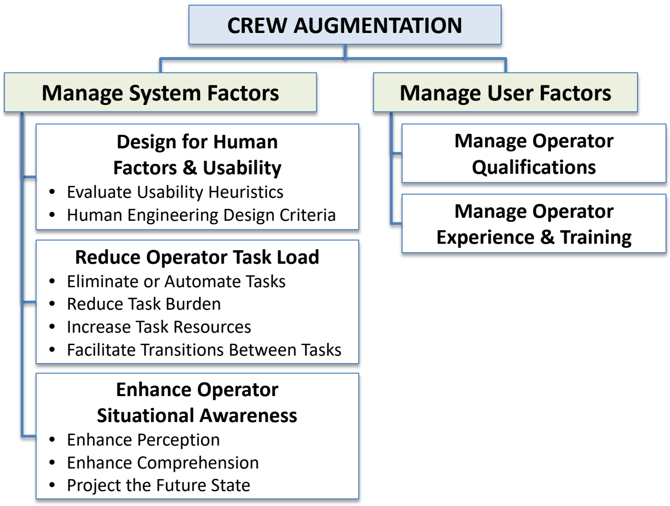

Figure 3: MET-D Crew Augmentation Functional Decomposition [4-5]

Design for Human Factors & Usability

The warfighter-machine interface (WMI) is an essential element of any crew-station, but even more so when considering a reduction in crew size. The MET-D two person crew-station was designed synergistically with human physical and cognitive capabilities and constraints taken into consideration in order to improve ease of use, reduce human errors and fatigue, and increase overall productivity.

Evaluation of usability heuristics – MET-D continually developed, tested, and solicited user feedback on usability of crew-station interfaces. Nielsen's Usability Heuristics were used extensively to guide detailed design decisions, particularly for the MET-D WMI software design [6]. His heuristics included areas of emphasis such as:

- Visibility of system status
- Match between system and the real world
- User control and freedom
- Consistency and standards
- Error prevention
- Recognition rather than recall
- Flexibility and efficiency of use
- Aesthetic and minimalist design
- Help users, recognize, diagnose, and recover from errors
- Help and documentation

Human Engineering Design Criteria – MET-D incorporated design criteria from the Department of Defense Design Criteria Standard- Human Engineering (MIL-STD-1472G) wherever possible. However, working within an existing system (Bradley M2A2 ODS-SA) as a surrogate vehicle platform imposed various constraints and compromises, such as designing based on 50th percentile US Army Male (deemed acceptable for the MET-D Project as a proof-of-concept demonstration).

One area of particular emphasis was the layout of the touchscreens due to their extensive use as a control interface as well display of indirect video used for driving and target engagement. Past TARDEC efforts have demonstrated significant performance improvement in indirect driving and the ability to negotiate obstacles when the ratio of camera angle to display angle is approximately 1:1 ("unity vision"). These proven benefits drove the overall crew-station layout shown in Figure 4, providing both Crew-1 and Crew-2 a set of displays with a near unity field-of-view for indirect driving. Note that although Crew-2 is provided unity vision displays, the crew-station is unable to perform indirect driving due to surrogate vehicle constraints. MET-D performance against human engineering design criteria is shown in Table 2.

Reduce Operator Task Load

Review of previous crew reduction studies showed limited success when the tasks associated with the baseline crew were simply reallocated to fewer crew persons (i.e., asking two persons to perform the tasks currently performed by three). In order to effectively augment two person crew performance, MET-D sought out ways to reduce operator task load. This was accomplished through a variety of means described herein.

Eliminate or automate tasks – In order to first understand current task load, the MET-D Project

Table 2: MET-D Crew-station Human Engineering Display Layout Design Criteria

Design Criteria [MIL-STD-1472G Ref]	MET-D
Mannequin Reference: Central 90th Percentile [5.8.1]	50th
Display Size (diagonal): 13in - 30in [5.2.3.1]	15.6in
Camera FOV / Display FOV Ratio: 1 ± 0.3 (T), 1:1 Unity (O)	1.25
Eye Reference Point (ERP) Viewing Distance: 13in - 30in [5.2.3.a, 5.2.3.c]	20.6in
ERP Max Horizontal Viewing Angle [Fig 25] ≤ 35° (T), ≤ 15° (O) eye rotation ≤ 60° head rotation ≤ 95° head & eye rotation	62.5°
ERP Nominal Vertical Line of Sight [Fig 2] (downlook from horizontal: 15°	7.7°
ERP Max Uplook View Angle* [Fig 25] ≤ 40° (T), ≤ 15° (O) eye rotation ≤ 66° head rotation ≤ 90° head & eye rotation	18.0°
ERP Max Downlook View Angle* [Fig 25] ≤ 20° (T), 15° (O) eye rotation ≤ 35° head rotation	2.86°
Latency: Roundtrip** ≤ 100ms (T), ≤ 75ms (O) [5.12.1.4.1]	90ms

* Relative to Nominal Line of Sight
** User input to display of system execution
All measurements taken from neutral seat position

created a catalog of existing functions associated with each workstation in the Bradley surrogate vehicle platform (i.e., Driver, Gunner and Commander). Rather than simply reallocating existing tasks to fewer crew, MET-D identified tasks that could be performed by the "System" (i.e., technology automation) rather than a human crewperson. The end result was a reallocation of tasks to Crew-1, Crew-2, as well as the "System" itself. Several MET-D automated task solutions include:

- Robotic driving (automated navigation and path following) and Drive By Wire subsystems;
- Automated scanning, target detection, tracking and classification using a Ground Movement Target Indicating (GMTI) radar;
- Maintain a threats list auto populated based on known threats sorted by threat priority
- Turret and/or CIV "slew-to-cue" capabilities to rapidly acquire targets detected in any video source, COP, threats list, etc.;
- Automated communication, including shared real-time status information of friendly networked units and auto report generation.

Reduce task burden – For tasks that couldn't be completely eliminated or automated, MET-D investigated means to make them less burdensome

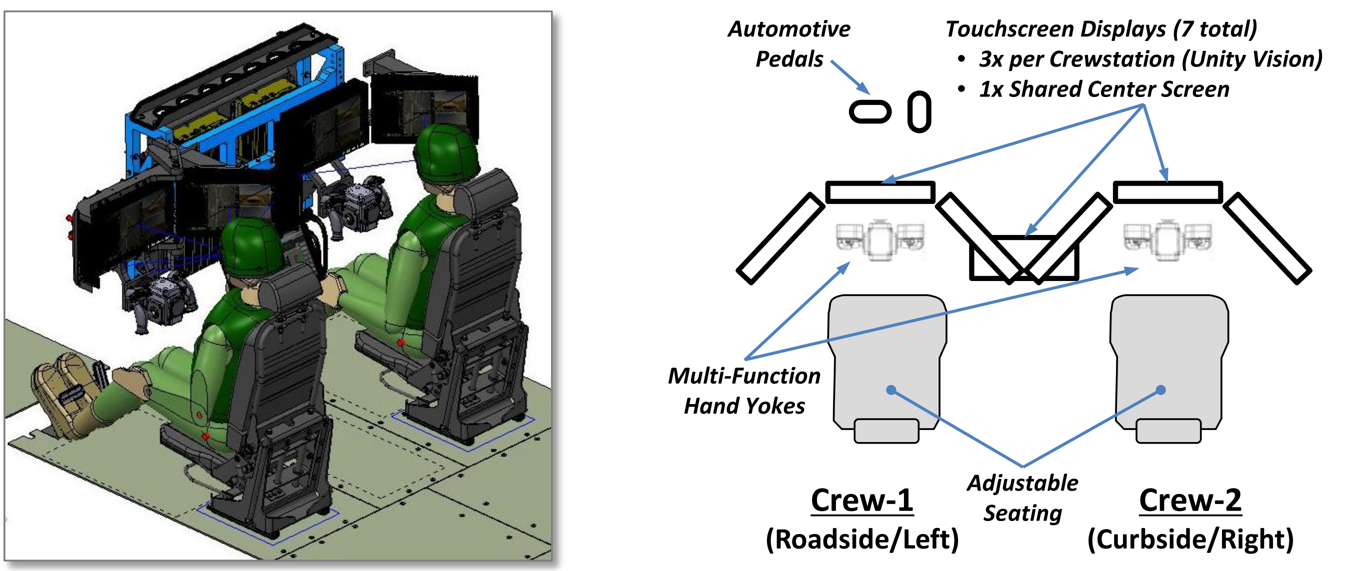

Figure 4: MET-D Crew-station Physical Layout. Key features include co-locating crew, independent unity vision displays complimented with shared display, modular software and multi-function hand yokes supporting tailored role-based interfaces.

and easier to complete (i.e., increase task efficiency). A few MET-D examples include:

- Co-locating crew and providing a shared display, which increases communication and teaming; compliment shared display with independent displays & interfaces that are reconfigurable (retain ability to work independently without distraction);
- Use of a bilateral control yoke versus a joystick to improve stability in dynamic environment and enhance fine pointing control for more efficient target acquisition, also avoids dominate hand preferences;
- Use of augmented reality to overlay battle space object entities, radar detections, friendly unity, waypoints, etc. directly on real-time video to augment spatial reasoning for navigation, target engagement and general situational awareness (reduce cognitive load to build and maintain “mental models” in order to fuse data).

Increase task resources - A third means to reduce task load is to increase available resources to complete the task, such as sharing or distributing the task across multiple crewpersons so as not to overburden any single individual. MET-D examples include:

- Shared real-time video and Common Operating Picture (COP) allowing crew, Squad, and/or friendly networked units to aid in local security and target detection;
- Integration of a Commanders Independent Viewer (CIV) in the MET-D modified M2A2 ODS-SA variant to regain the two person “hunter-killer” target engagement tactic (CIV not introduced until the Bradley A3 variant);
- Further augment hunter-killer tactics using crew-to-crew or squad-to-crew notifications (embedded slew-to-cue functions).

Facilitate transitions between tasks – Operation of a combat vehicle necessitates a diverse set of functions to move, shoot, communicate, survive, and mission command effectively. Evidence suggests operator performance can be significantly degraded when shifting between tasks in a multi-task domain such as in a combat vehicle [7]. MET-D intends to minimize inefficiencies in transitioning between tasks in multiple ways:

- Role-based interfaces and redundant functionality at either Crew-1 or Crew-2 realized through reconfigurable touchscreens, modular software, and multi-function hand yokes – allows crew to easy task organize to the current situation and tailor controls & display information to their current role;
- Ability for either Crew-1 or Crew-2 to immediately override arbitrated control authority services (Driver, IBAS/Weapons Operator, CIV Operator, UAS Operator) with a single action at any time (when safety constraint interlocks are satisfied);
- Ability to transition seamlessly between automated driving and manual driving, *and vice versa*, while on the move.

Enhance Operator Situation Awareness

MET-D adopts the definition of Situation Awareness proposed by Mica Endsley: “Situational Awareness is the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future” [4]. Using this definition, situational awareness provides the basis for all decision making and resulting actions, and therefor has the ability to significantly augment crew performance.

Enhance perception – MET-D integrates a number of sensors, and sensing technologies, to augment the Crew’s ability to perceive the operational environment:

- 360 local situational awareness camera array to provide video supporting indirect driving, local security, and target detection;
- Ground Movement Target Indicating (GMTI) Radar to provide automated scanning, detection, tracking, and classification of moving targets over an extended coverage area;

- On-demand, organic Unmanned Arial System (UAS) to provide Beyond Line-of-Sight (BLOS) visual surveillance in complex three-dimensional environments;
- Acoustic sensors and active noise cancellation to present Operators with audio of the ambient environment as if they were out of hatch;
- Proximity warning sensor to detect and alert Operators to the presence of objects behind the vehicle.

Enhance comprehension – Comprehension of perceived elements in the operational environment, not just sensing them, is necessary to translate relatively meaningless "data" into meaningful information and actions (i.e., "situational understanding"). Examples of how MET-D enhanced Crew Comprehension include:

- Shared real-time Common Operating Picture (COP) assimilates and fuses data from multiple sensors and networked systems into a holistic geospatially referenced model of the operational environment;
- Real-time digital markup of the COP ("Madden Draw") shared between Crew, Squad and/or friendly networked units promotes comprehension across the Unit improving overall collective "Team" situational awareness;

It should be noted that MET-D investigated technologies for automated target recognition and advanced fire control to aid comprehension but did not ultimately pursue these due to maturity and project resource constraints.

Enhance projection – Projecting the future state, based on perception and comprehension of elements in the current operational environment, will allow the Crew to identify the best course(s) of action to achieve mission goals. MET-D did not actively pursue technologies in this area due to cost and complexity. Future examples may include a combat artificial intelligence to sense, process and simulate the operational environment in real-time to provide Crew with probabilities and recommended courses of action for everything from path planning to target engagement.

Manage User Factors

Outside of System Factors, MET-D also acknowledges that crew performance may be augmented by considering User Factors (i.e., the crew themselves). Mechanisms such as increasing required cognitive qualifications and/or additional training and experience were identified as potential means to augment crew performance; however, these avenues were explicitly not considered. The MET-D two person crew-station goal was to not require aptitudes, skills, or capabilities beyond those currently present in the US Army Military Occupational Specialty (MOS) 11B general population.

DEVELOPMENT AND TESTING

To field an effective combat system for the soldier, it is not only the technology that is a factor on the success of the weapon/vehicle, but also how the soldier can use and interface to this technology. It is in this vein that it is imperative to involve representative soldiers early in the user interface design process. This process is best accomplished in a laboratory environment early in the design and development process, where soldier input can be

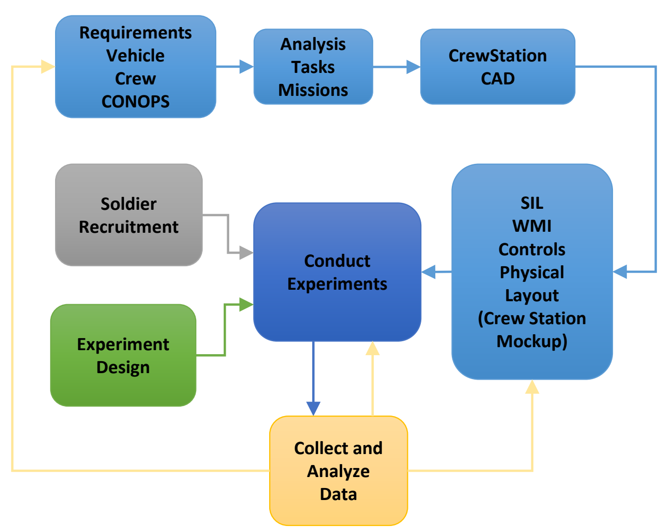

Figure 5: MET-D Experimental Design Process

funneled back into the design, as depicted in Figure 5.

During the development process, a System Integration Laboratory (SIL) is developed which accurately depicts the interior dimensions of the crew-station and its associated equipment. Once the SIL is developed, the human interface equipment, such as the monitors, yokes and pedals, can be added as shown in Figure 6.

Lastly, space claim mock-ups can be added to realistically reflect other items in the crew-station area that do not need to be part of the SIL experiments, but should be included to provide the "clutter" effect (radios, power converters, etc.). When the physical layout of the SIL is complete, the initial development of the WMI will be integrated into the SIL and its simulation environment (Figure 7).. This first iteration of this design is developed by engineers based upon best engineering practice and experience gained from previous crew-station development efforts along with the use of MIL-STD-1472G [1], which provides guidelines for the optimum placement of the human interface devices.

While engineers make every effort to develop a crew-station and WMI to meet the soldier's needs, it will be optimized using soldier feedback derived from crews using the new technologies in realistic military scenarios. This is accomplished by

Figure 6: MET-D System Integration Laboratory (SIL)

Figure 7: Sample WMI Screen Utilizing the VBS® 3 Simulation Software

immersing the crew and the crew-station into a virtual world using Virtual Battlespace 3® (VBS 3, Bohemia Interactive), which allows us the scripting of multiple scenarios. By placing soldiers in the crew-station and running them through the various scenarios, meaningful soldier feedback can be derived which then can be used to drive design changes to both the crew-station and the WMI. The MET-D team performed 8 weeks of soldier testing, spread over 2 years to obtain feedback and incorporate it into the design process (see Table 3).

Typically, for the MET-D experiments, 4 soldiers per week were brought up to TARDEC for testing. It was requested that the soldiers have Bradley commander and gunner experience. Upon arriving for the tests, the soldiers were asked to fill out Institutional Review Board documentation, received training with the SIL and WMI, then given a trial run to give them familiarity with how the testing would run. For the actual experiments, the soldiers were rotated through the SIL in groups of

Table 3: MET-D Soldier User Juries

Week	Date	Soldier Station Location
Wk 1	10-12 AUG 2016	Ft. Benning
Wk 2	20-22 SEP 2016	Ft. Bliss
Wk 3	27-29 SEP 2016	Ft. Bliss
Wk 4	24-26 APR 2017	Israel Ministry of Defense
Wk 5	02-04 MAY 2017	Ft. Benning
Wk 6	09-11 MAY 2017	Ft. Benning
Wk 7	18-20 AUG 2017	Ft. Benning
Wk 8	25-27 AUG 2017	Ft. Benning

two soldier crews. The crews received Operational Orders (OPORDS) to perform three distinct missions: defense, attack and movement to contact. The missions lasted anywhere from 30 – 60 minutes in length. After each mission, the crew was given a 15 minute After Action Review (AAR). Finally, on the third and final day of testing, a comprehensive AAR was conducted between the soldiers and the MET-D team.

As a combined result of the AARs and the observation of the engineers during the experimentation, a database of bug fixes and design comments was developed for MET-D. This list was broken into two categories: SIL comments/fixes and MET-D design input. It is interesting to note that the most significant physical design changes based upon the soldier user juries was the crew-station design utilizing a total of seven monitors instead of the proposed five monitors and also the soldier led design of the crew-station yokes (Figure 8). The WMI received much feedback which was incorporated into its design and had been receiving continuous updates over the past two years.

CONCLUSIONS AND FUTURE WORK

The MET-D program focused on the demonstration of spilt-squad technologies and closed hatch operations. TARDEC Engineers utilized Mission Engineering; Crew Augmentation & Design; and Development and Testing techniques to decompose crew member task, design crew augmentations, design and build a crew station SIL and design and execute soldier based experiments to refine the MET-D vehicle crew stations. The MET-D will conduct field experimentation at Ft. Stewart, GA later this fall to evaluate the reduced crew concept and split squad technologies in order to shape requirements for future fighting vehicle programs.

The MET-D program will be conducting a 30 day experiment that covers a wide breadth of activities that consist of tactile driving, gunnery tables, situational training exercises (STX) at the section and squad level and a full platoon exercise. These experiments will consist of comparing a baseline section of vehicles, M2A3's, against the MET-D Section 2 vehicles which are modified M2A2 ODS SA's that have had the Commander Independent Viewer (CIV) added to ensure both sections have the hunter/killer capability. The MET-D vehicles can be operated in both two person crew and three person crew configurations which allow increased flexibility in the design of the scenarios maximizing the data collected for further analysis.

Figure 8: MET-D Crew-station Hand Controller (Yoke) Design Based on User Jury Input

The driving event will be based on collecting performance metrics such as time to complete the course, penalties for cones hit and departure from the course. The MET-D vehicles will be driven from the Crew1 seat under closed hatch while the baseline vehicles will be driven from the traditional driver's seat with both closed and open hatch runs. Gunnery will be performed under closed hatch with both 2 and 3 person crews operating the MET-D vehicles. Metrics such as time to detection, time to engagement and accuracy will be used to score the event and compared to the baseline configuration. The Squat STX will be run in using the baseline BFV vehicle as well as the MET-D vehicles utilizing both Two Person Crew and Three Person Crew configurations and will use a wide variety of metrics for comparison. The platoon exercise will consist of all six MET-D vehicles being used simultaneously which will highlight the benefits of having a platoon of networked vehicles with greatly increased situational awareness.

After each event, the Soldiers will complete multiple surveys on their experience, stress levels and feedback. During the event they will be wearing bio-metric armbands to collect data as they progress through the experiment to better correlate with the user surveys. Finally the data will be aggregated with the performance metrics to build a clear picture of the performance enhancements that the MET-D vehicles have achieved.

In addition to the MET-D technologies, recent advances in autonomy, artificial intelligence and machine learning will change the nature of the battlefield, it will change the very nature of the tasks the Soldiers perform, and thus the capabilities the Soldiers need. Future Army R&D efforts in this area will conceive of not only the potential capabilities of future intelligent technologies, but the potential for completely new interactions amongst heterogeneous teams of Soldiers and intelligent agents.

These future manned and unmanned teams will need to complete the missions of current Soldier only teams, but with greater resilience, faster decision making, and faster team reconfiguration to meet mission demands, and reduced risk to Soldiers. TARDEC and the Army Research Laboratory are teaming to develop crew-centered technologies to enable Soldiers to intuitively and dynamically collaborate with intelligent technologies (intelligent agents) and each other to handle the broad range of task requirements.

ACKNOWLEDGMENTS

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