

# COGNITIVE DECISION AIDS FOR GROUND COMBAT VEHICLES

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## Abstract

This paper describes an effort by the US Army to apply cognitive decision aids to ground combat vehicles in a program entitled Crew integration & Automation Testbed. Based on a generic intelligent complex ground vehicle taxonomy, workload modeling is conducted to identify peak areas of crew workload. Analysis of specific tasks during peak workload conditions allows the application of specific workload reduction measures, including decision aiding, to improve task loading.

## Keywords

Automation, decision aids, intelligence, interface, workload.

## 1 Introduction

The Army is pursuing cognitive decision aids as part of a new program entitled Crew integration & Automation Testbed (CAT). One of the Army's seventeen Advanced Technology Demonstration (ATD) programs, the CAT will employ decision aids to allow a two-soldier crew to operate multi-mission capable systems envisioned for the Army's future combat vehicles. The goal is to develop crew stations that are equally effective in the fight, scout and infantry carrier missions. The Army currently uses a unique system for each of these missions with crew sizes ranging from three to four soldiers per vehicle.

The decision aids will be integrated along with emerging soldier-machine interface designs and devices, in-vehicle crew training/mission rehearsal technologies and an advanced electronics architecture for soldier testing and evaluation. Fig. 1 illustrates the program's concept demonstration vehicle (shown with a third operator onboard for safety).

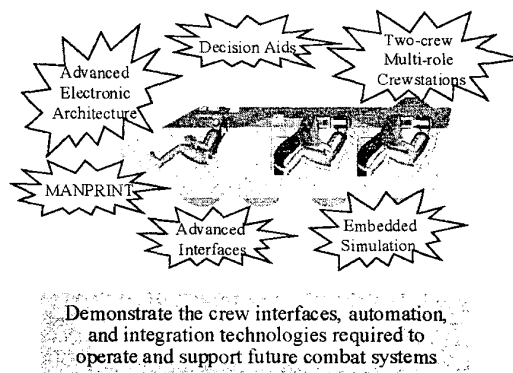


Fig. 1: Crew integration & Automation Testbed (CAT)

## 2 Intelligent Complex Ground Vehicle Model

TARDEC's Vetronics Technology Area has mission responsibility for applied technology development for reduced crew operations for future combat systems. To support this effort, it has developed a model for these intelligent complex ground vehicles that allows them to be characterized in a non-system specific and repeatable manner. Fig. 2 illustrates key aspects of the Intelligent Complex Ground Vehicle (ICGV) model that relate to the CAT workload analysis effort [1].

## 3. Workload Modeling

The first key premise related to CAT is the explicit multi-tasking model. It is this aspect of the ICGV that allows the event-driven and concurrent task execution nature of the ICGV domain to be captured and modeled. It is important that this behavior is systematically and comprehensively

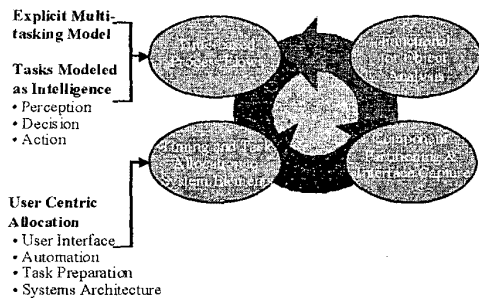


Fig. 2: Intelligent Complex Ground Vehicle Model

captured to design both workload aids for the human operator and automated subsystems. As more and more automated subsystems are being developed to aid the operator, it is critical to make sure that these functions can represent either human or machine intelligence. Fig. 3 shows the multi-perception model of the ICGV that initiates the execution of individual actions or threads.

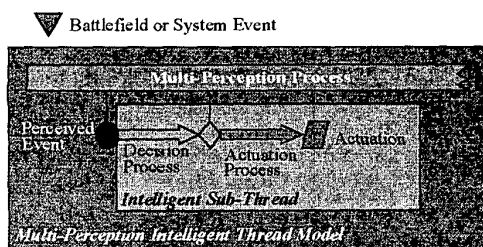


Fig. 3: ICGV Multi-Perception Model

To support the CAT program, computer workload modeling and analysis is being conducted by the US Army Research Laboratory's Human Research & Engineering Directorate (HRED) to study the workload associated with the fight, scout and infantry carrier roles, as well as the envisioned role of controlling unmanned air and ground assets.

Seven mission scenarios have been generated in cooperation with the Mounted Maneuver Battlespace Battle Lab at Ft. Knox that cover fight, scout and carrier missions. Next, functional analysis was conducted according to the described model.

Timing data was assigned to each function based on current system baselines, required task timelines, or based on subject matter expert analysis. For future system design work, timing data can also be derived

from system level performance specifications for each function.

HRED utilized the seven scenarios, baseline models of the existing Army tank, scout and carrier vehicles, and a conceptual two-soldier crew station being developed by TARDEC to conduct the workload analysis.

HRED utilized IMPRINT to build an advanced workload task network model of each of the baseline vehicles and the two-crew concept. For each of these tasks, researchers entered workload values on a 7-point scale into the IMPRINT model. Based on these values, the IMPRINT software calculated workload predictions for each operator as they performed the tasks associated with each function. The researchers then examined these workload predictions to see if they exceeded acceptable workload levels of 40-60. A mental workload level of 40 is considered to be acceptable for an inexperienced operator and a workload level of 60 is acceptable for an experienced operator. When workload values exceed these levels, then the crewmembers' mental workload may adversely effect their performance during the mission.

Preliminary results for the current Army fire, scout and infantry carrier vehicles indicate that workload is relatively low for all crew positions within these vehicles. The commander's position exhibits peaks of up to 50% over the average workload, but does not leave an acceptable range.

In the two-crew model, the commander was assigned the functions of driving, monitoring communications from higher headquarters, scanning for targets, communicating with the gunner, and performing all command tasks associated with the mission, e.g. developing fire plan, planning routes, etc. The gunner was assigned the functions of scanning for targets, communicating with the commander, engaging targets, and destroying targets. Fig. 4 shows a sample of peak workload from the first tank mission scenario [2].

The first iteration of a multi-mission capable system shows a 100% increase in workload, underscoring the requirement for aids to the crewmen. In addition to cumulative workload, the model also allows us to look at active tasks being conducted at any point during the mission. Fig. 5 shows the tasks being conducted during the peak

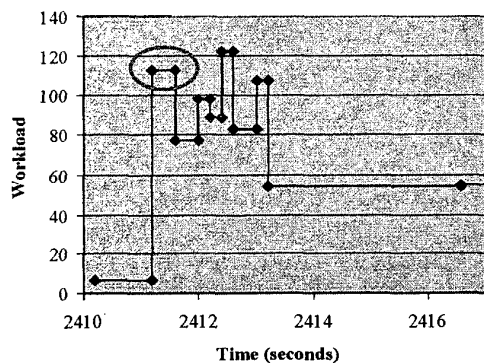


Fig. 4: Peak Workload Condition Sample

workload condition indicated in Fig. 4 [2]. In this figure, the shaded tasks are active, the arrows show tasks being conducted at more detailed levels of the model, and TC represents Tank Commander.

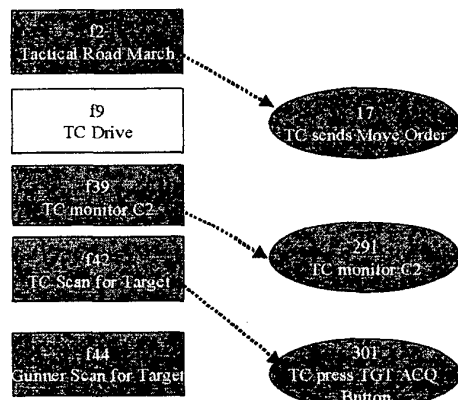


Fig. 5: Tank Mission at run time 2411.2

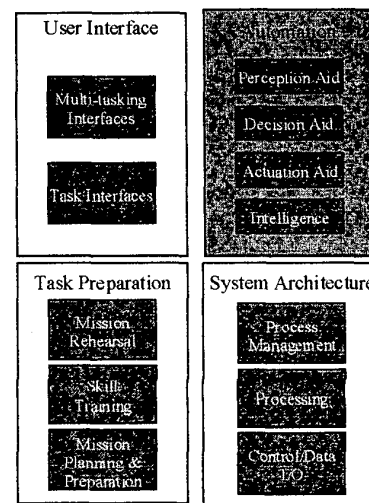
In this example, the commander's workload exceeds 100 when he drives, scans for targets, and monitor communications simultaneously. The model results indicate another peak in workload occurs when the commander is trying to relay a digital message, scan for targets, and monitor C2 simultaneously. In both cases, his workload numbers exceed the acceptable workload range and indicate that high workload levels could adversely affect the tank commander's performance during a mission. Therefore, these situations should be targeted for workload reduction.

#### 4 Workload Reduction

The second key premise in the ICGV related to CAT (reference Fig. 1) is the User-Centered Allocation, in which the fundamental means of aiding crew are:

- Improving the user interface
- Adding automation
- Improving a priori preparation
- Improving system architecture

These system elements can further be delineated as shown in Fig. 6. The CAT ATD will address each of these elements with an emphasis on automation and in particular the use of decision aids. The choice of decision aids will be driven by the results of the



workload analysis activity.

Fig 6: Workload Reduction Methods

For the peak workload condition illustrated in Fig. 4, the areas of driving, command and control and target acquisition may be targeted for automation or decision aiding.

For the CAT ATD, TARDEC will leverage decision aids developed by other Army agencies as they related to the mission areas of those agencies. Examples of leveraged aids include automated target acquisition systems, integrated survivability systems, and combat (friend or foe) identification systems.

TARDEC will also conduct specific development of a driving aid. This aid will have an automated mode in which the crew can offload the driving task and only monitor its performance. This mode will reduce workload during simple movements between battle locations and offer periods of rest and relief that will be vital to reduced crew operations over extended periods.

The driving aid will also have a decision aiding mode in which the crew member will retain driving control but receive additional information to assist them while they are performing other functions and not devoting full attention to driving. This information could consist of visual cues of obstacles detected by the system, haptic feedback making indicating that the driver is steering toward an obstacle or off a road, or three-dimensional audio indicators of other vehicles in the platoon that will help him stay in formation.

## **6 Conclusions**

The Army is moving toward reduced crew combat systems that will have significantly higher workload than current systems. Computer workload analysis indicates that, unaided, crews will not be able to efficiently handle the workload associated with these systems. To address this challenge, the Army is pursuing cognitive decision aids in a new program entitled Crew integration & Automation Testbed (CAT). These decision aids, combined with advanced soldier-machine interfaces, embedded simulation and an integrated electronic architecture will allow a two-soldier crew to operate multi-mission capable systems envisioned for the Army's future combat vehicles.

### **References:**

1. C. Adams, An Intelligent Complex Ground Vehicle Taxonomy.
2. D. Mitchell and J. Lockett, Preliminary Results of CAT Workload Modeling and Analysis.