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An Analysis of the Abilities Required by Future RSTA Vehicle Commanders and Drivers

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14. ABSTRACT

Abilities needed by future commanders and drivers of reconnaissance, surveillance, and target acquisition (RSTA) vehicles were examined in a soldier-in-the-loop simulation of a Future Combat System unit of action. We used the Job Assessment Software System to administer the abilities taxonomy developed by Fleishman and Quaintance (2000). We found that in the simulation used, (a) vehicle drivers needed a higher level of overall abilities than the vehicle commanders; (b) vehicle commanders' jobs appeared to become easier with experience, while those of the drivers did not; and (c) conceptual, communications, and speed-loaded abilities were the most critical abilities for vehicle commanders and drivers. We recommend changes in human factors engineering, training, and personnel selection to improve performance of RSTA vehicle commanders and drivers.

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1. Introduction

1.1 Overview

The abilities required to maintain situation awareness as the commander or driver of a reconnaissance, surveillance, and target acquisition (RSTA) vehicle were examined for future Army operations as described in the Objective Force concept. Situation awareness or situation understanding (SU), as situation awareness is referred to by the Army, is key to the Objective Force concept (Department of the Army, 2002). Situation awareness is the perception of relevant objects in the environment, comprehension of the overall situation, and projection of what will happen in the near future (Endsley and Garland, 2000). This research was conducted because reconnaissance tasks in the Objective Force will be much different than current reconnaissance tasks, particularly at the vehicle commander and driver level. Reconnaissance tasks will involve much more sensor management and use of displays, compared to current scouting tasks. As such, different abilities may be involved or at least differences in importance among the current abilities used. We wanted to examine abilities that are important for future RSTA vehicle commanders and drivers, to ascertain if those abilities are the same for both positions, and if the amount of those abilities needed changes with training. These questions are important, since the Army needs to design equipment and select and train personnel for the abilities needed in the Objective Force environment. The report begins with a brief overview of the Objective Force environment and how the RSTA vehicle crew is critical to this environment. We then discuss the area of human performance taxonomies as a method to determine the ability requirements for jobs. Next, we review the experiment in which we participated, the data collection method, and results. Finally, we present conclusions and recommendations related to changes in human factors engineering, training, and selection, which could enhance performance concerning the abilities required for RSTA commanders and drivers.

1.2 Objective Force Environment

The Objective Force will be a strategically deployable, tactically superior and sustainable force that will provide a quick reaction capability for a continuum of conflicts that arise in the 21st century. The Objective Force is envisioned to be a mixture of manned and unmanned combat systems. This force will incorporate and exploit information dominance to develop a common, relevant operating picture and achieve SU to dominate the battlespace. The Future Combat Systems (FCS) that comprise the Objective Force will have to be relatively light (20 tons) and small in order to be deployed quickly and sustained efficiently.

The Objective Force's success in combat will depend on soldiers' seeing and killing the enemy at a distance, as opposed to closing with and destroying the enemy. In order to detect and engage the enemy at a distance, extensive use of sensor-equipped aerial or ground robotic vehicles will be needed. Personnel will use operational control units (OCUs) to control robotic vehicles, and by doing so, will be able to detect, classify, recognize, identify, and engage the enemy and report battle damage and maintain SU. In addition to the OCU operator, someone will need to drive and position the vehicle and act as gunner to defend the vehicle from unanticipated, close range threats.

The enhanced sensor and network-centric information gathering capabilities of the Objective Force are focused on maintaining SU. SU is the basis upon which individuals and commanders make decisions and adapt to changes in the environment. Thus, without the ability of soldiers to maintain SU, the sophisticated sensor and weapons systems of the Objective Force are of substantially less value.

1.3 Human Performance Taxonomies

In order for the Army to select, assign, train, and equip RSTA vehicle commanders and drivers, it is necessary to determine what abilities are used to perform these jobs. Fleishman and Quaintance (2000) describe a variety of taxonomies of human performance or ways to categorize human performance capabilities. One approach is called "ability requirements." Under this approach, tasks are described in terms of the abilities necessary to perform them and tests are used to assess the required abilities. These tests are then factor analyzed to identify common factors among groups of tests. These common factors are interpreted as abilities according to the factor loadings of the tests on the factors. Numerous physical and mental abilities have been documented with this approach. Research, described by Fleishman and Quaintance (2000), has established statistically significant relationships between abilities identified by factor analysis and learning and performance of a job.

Another use of abilities taxonomies is to determine the abilities necessary to perform specific jobs. First, a description of an ability and examples of various levels of that ability are developed (see Table 1). Then, job incumbents and experts are asked to rate how much of that ability is necessary to perform the job being rated. Research described by Fleishman and Quaintance (2000) demonstrates good levels of agreement (correlations in the .60 to .80 range) between ratings by job incumbents and experts of abilities required by a specific job. This method of ability rating is used in the research described in this report.

Table 1. Example of an ability rating scale

Written comprehension: The ability to understand written words, sentences, and paragraphs

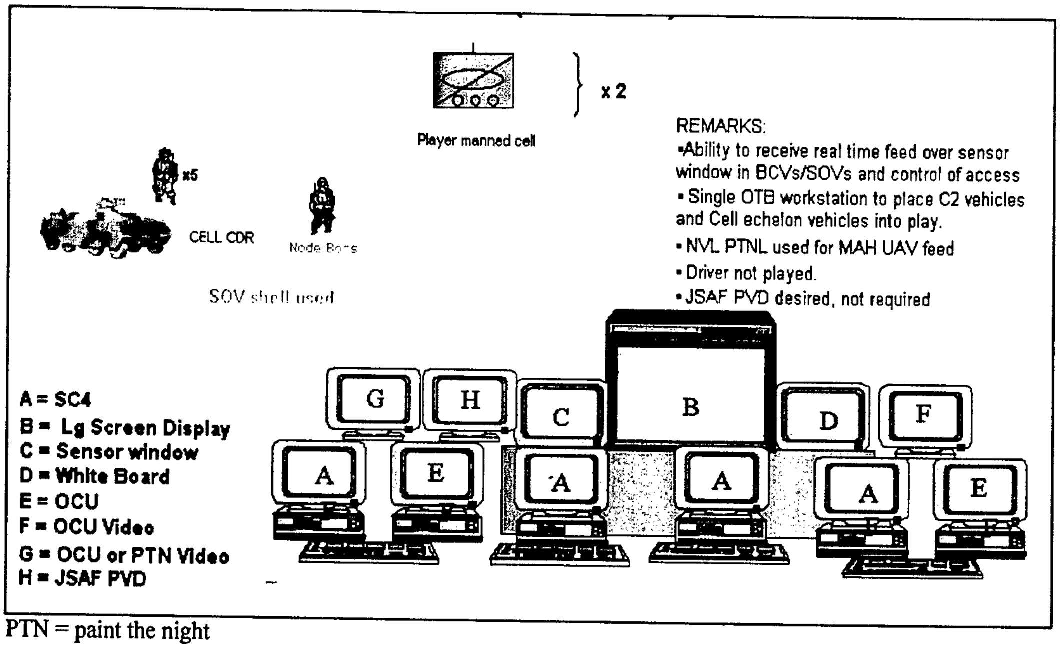
How much of this ability is needed to perform the job?

Understand an instruction book about repairing a missile instrument system	7 A great amount of this ability is needed
	6
	5 Quite a bit of this ability is needed
Understand an apartment lease	4
	3 A moderate amount of this ability is needed
	2
Read the words on a roadmap	1 A minimum amount of this ability is needed

1.4 The Future Combat System Experiment

The Army will, in partnership with the Defense Advanced Research Projects Agency, develop Objective Force systems concepts, perform experiments to validate and refine those concepts, and conduct technology demonstrations. This report addresses data collected during an FCS experiment on command, control, communications, computer, intelligence, surveillance, and reconnaissance. A range of scenarios was used in the experiment run by the Institute for Defense Analysis (IDA). Although the U.S. Army Research Laboratory collected the data described in this report, it was not in charge of the experiment. The RSTA vehicles in this experiment were virtual simulations in the Mounted Maneuver Battlespace Lab at Fort Knox, Kentucky.

In this experiment, there were two manned cells (a company-sized element), with six RSTA vehicles each (see Figures 1 and 2). The RSTA vehicles each possessed several robotic ground and aerial sensors that could be controlled through the OCU. These RSTA vehicles were the primary means of target acquisition for the cells, although the cells had some other sensor capabilities that belonged to the cell, as well as weapon systems to engage the targets at long ranges. The two manned cells, plus four unmanned (constructive) cells, which were each controlled by one person, composed the unit of action (a battalion-sized entity in this research). The unit of action provided overall command and control, possessed additional organic sensors and long-range weapons, and provided access to higher level sensors (e.g., satellites) and weapon platforms (e.g., B-2 bombers). A central European terrain base was used to simulate a variety of traditional and asymmetric scenarios. Peacekeeping and disaster relief were not simulated.

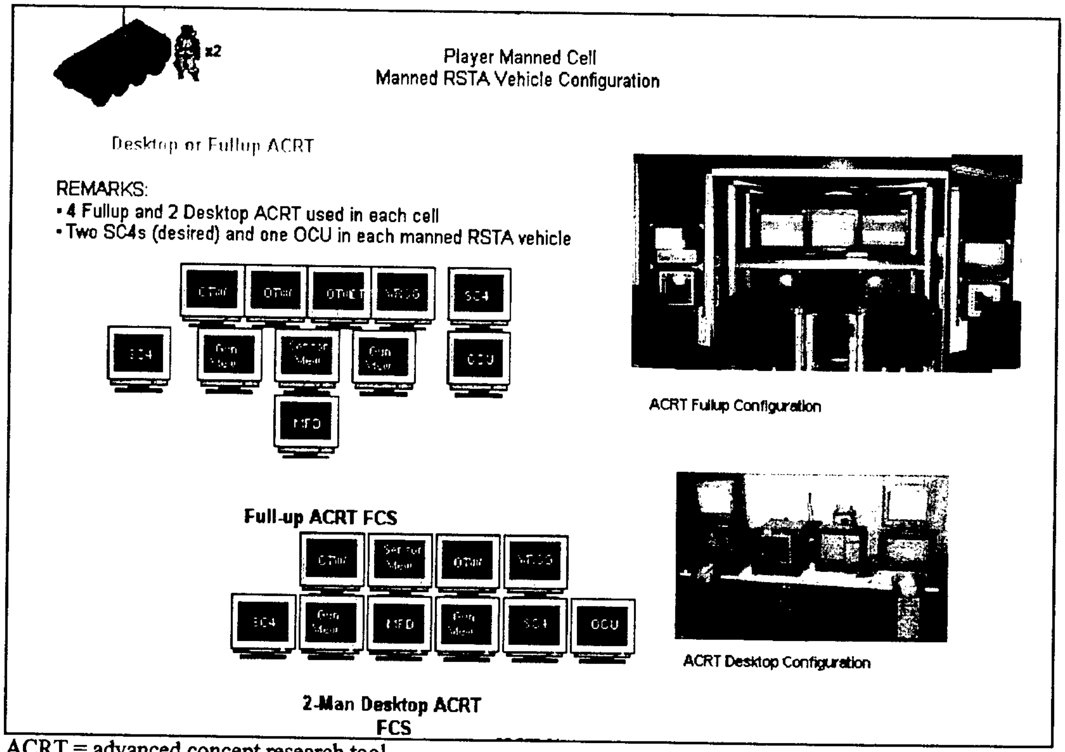


REMARKS:
- Ability to receive real time feed over sensor window in BCVs/SOVs and control of access
- Single OTB workstation to place C2 vehicles and Cell echelon vehicles into play.
- NVL PTNL used for MAH UAV feed
- Driver not played.
- JSAF PVD desired, not required

A = SC4
B = Lg Screen Display
C = Sensor window
D = White Board
E = OCU
F = OCU Video
G = OCU or PTN Video
H = JSAF PVD

PTN = paint the night
JSAF PVD = joint semi-automated forces plan view display
BCV = battle command vehicle
SOV = staff operations vehicle
OTB = one semi-automated forces test bed
NLV PTNL = night vision lab paint the night light
MAH UAV = medium altitude helicopter unattended aerial vehicle

Figure 1. RSTA vehicle sensor suite.



REMARKS:
- 4 Fullup and 2 Desktop ACRT used in each cell
- Two SC4s (desired) and one OCU in each manned RSTA vehicle

ACRT = advanced concept research tool
OTW = out-the-window view
VSRG = virtual reality signal generator

Figure 2. Interior of simulated RSTA vehicle.

Crew tasks were divided between the vehicle commander and the driver. The vehicle commander operated the OCU and directed the driver in positioning the vehicle. Route planning was impromptu. In general, the vehicle commander received a request for information about a certain part of the area of operation from the cell level. The commander then directed the driver to move to a certain location (if applicable) and deploy the sensors. The commander had a computer workstation that functioned as an OCU. Primarily using a mouse, the commander could navigate through a menu to deploy ground and aerial sensors, design routes for these sensors, change direction or stop them en route, or even give control of vehicle sensors to another commander or take control of another vehicle's sensors (provided the other commander relinquished control). Any entities detected by these sensors automatically appeared on the OCU screen. Different sensors could provide different levels of target acquisition from detection (something man-made) to classification (e.g., wheeled versus tracked vehicle), to recognition (e.g., enemy versus friendly) to identification (BMP 90). The commander could then transfer targets to the cell for engagement or could engage with one of the weapon systems under his control (non-line of sight mortar). In addition to the OCU, the commander had access to a command and control computer called a simulated command, control, communications, and computer (SC4), which provided a "common operating picture" based on information about a variety of entities provided by a wide variety of sensors, over the entire battlespace. Some of these sensors were controlled by the cell, and others were not. Another important aspect of the vehicle commander's job was to communicate with the driver, other vehicle commanders, or cell personnel via a headset.

The driver of the simulated RSTA vehicle had typical vehicle controls (gear shift, accelerator, brake, steering wheel) as well as several outside views of the vehicle. The driver also had a 30-millimeter gun for defense of the vehicle. The gun was (conceptually) on the vehicle turret and was controlled by a screen in front of the driver. In addition, the driver had the same SC4 and headset capabilities as the commander. The driver could also switch modes and control robots if the commander needed assistance, although he had to look across the vehicle to view the OCU screen in order to do so. No written job descriptions were provided for either crew member.

The experiment was conducted from 17 September 2001 to 18 January 2002 in four sets of 2-week trials. Each trial occurred 3 weeks apart. The first trial (17 September to 5 October) was devoted to familiarization with the Objective Force environment and individual skills training. For example, crew members learned how to use the OCU software and how to drive the RSTA vehicle. The second trial (29 October to 9 November) concentrated on collective skills training. Crew members learned how to function as an OCU operator in a cell and how to function as a commander-driver team. The second trial culminated with a pilot scenario. The third (3 to 14 December) and fourth trials (7 to 18 January) involved operational Objective Force scenarios.

Scenarios involved attack and defend missions in a central European area and were fought against opposing force personnel with semi-automated computer forces. Missions lasted about 8 to 12 hours.

2. Method

2.1 Participants

Participants were 12 RSTA vehicle commanders and 11 drivers who participated in trials 2 and 3 of the Objective Force experiment described before. One driver did not complete the second administration of the survey. All but two of these individuals (one commander and one driver) were from National Guard (NG) units. The NG participants lived in the Fort Knox area and had participated in other Battle Lab experiments. The active duty participants worked for IDA. Selected demographics are presented in Table 2.

Table 2. Selected demographics

Rank	**Vehicle Commanders**	**Drivers**
E6	3	0
E5	3	3
E4	6	7
E3	0	1
Age		
< 20	0	1
20 to 25	3	3
26 to 30	4	4
31 to 35	2	1
> 35	3	2
Civilian Education		
non-high school graduate	0	1
high school graduate	3	5
some college	5	5
college graduate	4	0
Time in Guard		
not applicable	1	1
< 1 year	3	2
1 to 2 years	3	4
> 2 to 5 years	1	3
> 5 to 10 years	4	1

2.2 Instrument

The particular human abilities taxonomy used, shown in Table 3, was based on one developed by Fleishman and Quaintance (2000) and modified by Knapp and Tillman (1998). This taxonomy has two major groups of ability clusters (cognitive skills and experience and perceptual motor). Each of these main groups contains four ability clusters (as in Table 3). The ability clusters in turn contain from three to ten specific skills. There were 50 specific skills in all. The taxonomy was administered via a computer program called the Job Assessment Software System (JASS). Individuals were presented a series of "yes/no" questions that asked which specific skills were necessary to perform a job. For example, in order to perform the job, is it necessary that the person know and use language? If an individual indicated that a skill was not used, the computer program did not present that skill to be rated, and the skill was given a 0 rating. If an individual indicated that a skill was used, individuals then rated the relevant skill on a scale similar to the one in Figure 1. Individuals could move a cursor to set the level of ability needed on a 1 to 7 scale. In this experiment, all participants addressed the task of "maintain situational understanding." This was defined as "being aware of the location of your own units, enemy units, and the commander's intent in order to perform the mission".

JASS has been used to determine abilities required for a variety of jobs such as home health care professionals (Knapp and Tillman 1998) and M1A2 System Enhanced Package (SEP) crew members (Gill et al., 1999). For the M1A2 SEP, results showed that skill demands in the area of maintaining SU were reduced by additional digital capabilities of the M1A2's inter-vehicular information system.

Table 3. JASS ability clusters and skills

Cognitive Skill and Experience Clusters			
Communications	**Conceptual**	**Reasoning**	**Speed-Loaded**
1. Oral comprehension	5. Memorization	13. Inductive reasoning	19. Time sharing
2. Written comprehension	6. Problem sensitivity	14. Category flexibility	20. Speed of closure
3. Oral expression	7. Originality	15. Deductive reasoning	21. Perceptual speed/ accuracy
4. Written expression	8. Fluency of ideas	16. Information ordering	22. Reaction time
	9. Flexibility of closure	17. Mathematical reasoning	23. Choice reaction time
	10. Selective attention	18. Number facility	
	11. Spatial orientation		
	12. Visualization		
Perceptual-Motor Ability Clusters			
Vision	**Audition**	**Psychomotor**	**Gross Motor**
24. Near vision	31. General hearing	35. Rate control	41. Extent flexibility
25. Far vision	32. Auditory attention	36. Wrist-finger speed	42. Dynamic flexibility
26. Night vision	33. Sound localization	37. Finger dexterity	43. Speed of limb movement
27. Visual color discrimination		38. Manual dexterity	44. Gross body equilibrium
28. Peripheral vision		39. Arm-hand steadiness	45. Gross body coordination
29. Depth perception		40. Multi-limb coordination	46. Static strength
30. Glare sensitivity			47. Explosive strength
			48. Dynamic strength
			49. Trunk strength
			50. Stamina

2.3 Procedure

Participants completed the JASS after they completed individual and collective training on trial 2 and a second time during the first week of the third trial. The second administration of the JASS was originally scheduled for the second week of trial 3 but was given earlier at the request of the experiment leader. After completing the day's mission, participants completed the JASS on stand-alone computers in a briefing area. Vehicle commanders rated abilities requirements on seven tasks, and drivers rated abilities requirements on two tasks. The data in this report are a comparison of ratings on the only task rated in common: maintain situational understanding. This task was the first task rated by vehicle commanders and drivers.

2.4 Analyses

The data were analyzed with a 2 x 2 x 8 between- and within-subjects' analysis of variance (ANOVA) factorial design. The between-subjects factor was position (vehicle commander or driver). The two within-subjects factors were administration (first versus second) and ability clusters (one through eight, as in Table 3). The alpha level chosen for statistical significance was $p < .05$.

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3. Results

Table 4 presents ability cluster means and standard deviations broken down by position and administration.

Table 4. Ability cluster means and (standard deviations) by position and administration

Cluster	First Administration Vehicle Commander	First Administration Driver	Second Administration Vehicle Commander	Second Administration Driver
Conceptual	3.57 (1.42)	4.04 (1.60)	2.76 (1.70)	4.18 (1.24)
Communication	3.33 (2.07)	3.35 (1.91)	3.09 (2.02)	4.33 (.96)
Reasoning	2.56 (2.19)	3.33 (1.55)	1.04 (1.16)	2.81 (1.80)
Speed loaded	3.13 (1.60)	3.50 (1.57)	2.02 (1.28)	3.68 (.90)
Audition	2.34 (2.25)	3.05 (2.16)	1.36 (1.92)	3.17 (2.11)
Vision	3.51 (2.36)	4.43 (1.75)	1.99 (2.19)	3.95 (1.55)
Psychomotor	2.27 (1.49)	3.17 1.83)	1.47 (1.29)	3.15 (2.35)
Gross motor	0.23 (0.27)	1.81 (1.57)	.11 (.23)	2.34 (2.27)

3.1 Position

The main effect for position was statistically significant (F (1, 21) = 5.73, $p < .05$). The overall mean (averaging over all eight clusters and both administrations) was higher for drivers (M =

3.39) than for operators (M = 2.17). However, there was also a statistically significant Position × Administration interaction (F (1, 21) = 7.34, $p < .05$). As shown in Table 5, while the mean for vehicle commanders decreased from the first to second administration, the mean for drivers slightly increased.

Table 5. Overall cluster means by position and administration

Administration	**Vehicle Commander**	**Driver**
First	2.62	3.34
Second	1.73	3.45

3.2 Administration

The main effect for administration was statistically significant (F (1, 21) = 4.31, $p < .05$). The overall mean (averaging over all eight clusters and both positions) was higher for the first administration (M = 2.98) than the second (M = 2.59). However, as noted before, there was a statistically significant Position × Administration interaction so that the decrease between administrations was only for vehicle commanders. Further repeated measures ANOVAs by position showed that the difference between administrations was statistically significant only for vehicle commanders (F (1, 11) = 9.20, $p < .05$).

3.3 Ability Clusters

The main effect for ability clusters was statistically significant (F (1, 7) = 15.55, $p < .001$). There were no statistically significant interactions among ability clusters and either position or administration. Table 6 shows the results of paired comparisons between overall cluster mean estimates (averaging over both survey administrations and both positions). Clusters within the same box do not differ significantly ($p < .05$). Clusters in different boxes do not differ significantly unless they have the same subscripts (a or b). Results suggest that conceptual, communication, vision, and speed loaded are the most important clusters for both positions, over both administrations because of their high scores.

Table 6. Overall ability cluster means

Cluster	**Estimated Mean**
Conceptual	3.63
Communication (a)	3.52
Vision (a)	3.47

Speed loaded (a, b)	3.08

Psychomotor	2.52
Audition (b)	2.48
Reasoning	2.44

Gross motor	1.12

3.4 Comparison to Related Duties

In order to provide an idea of how skills for the (future) RSTA crew members compare to skills for a known duty, we compared cluster scores of RSTA commanders and drivers with cluster scores of four M1A2-SEP commanders and four drivers. The M1A2 SEP crews operated actual vehicles, not simulations. The M1A2 SEP data were obtained during materiel testing in November 2000. For the RSTA crew, we used scores on "maintain SU" (the only task discussed in this report) from the second administration. For the M1A2 SEP commander and gunner, we also used the cluster scores for "maintain SU" from the only administration of JASS. Because of the small number for scores for the M1A2 SEP participants (n = 4), no statistical comparisons were attempted.

Figure 3 shows the results for vehicle commanders. RSTA commanders had substantially higher scores on communication, vision, audition and psychomotor clusters, and comparable scores on conceptual, speed loaded, reasoning and gross motor clusters. The M1A2 commanders did not have substantially higher scores on any clusters.

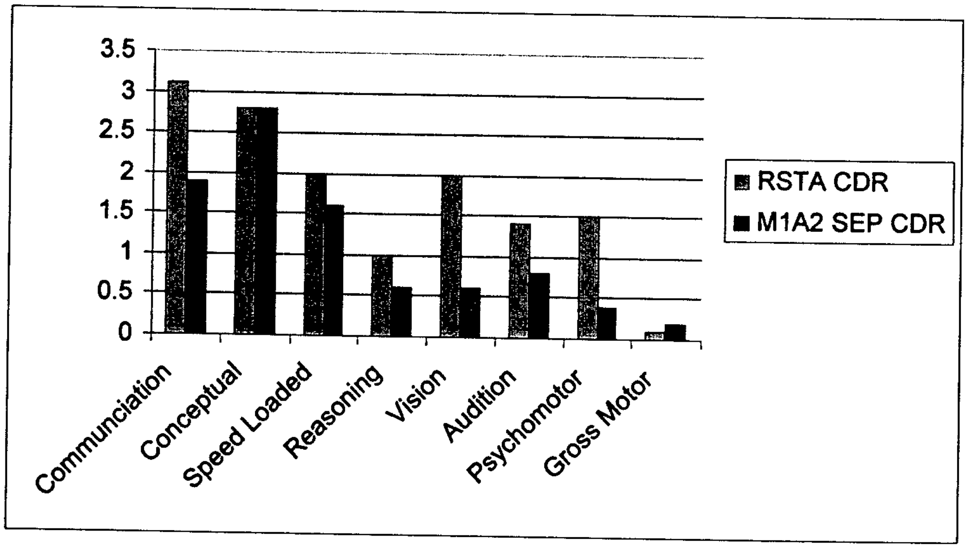

Figure 3. Cluster scores for RSTA and M1A2 vehicle commanders.

Figure 4 shows the results for vehicle drivers. RSTA drivers had substantially higher scores on all clusters.

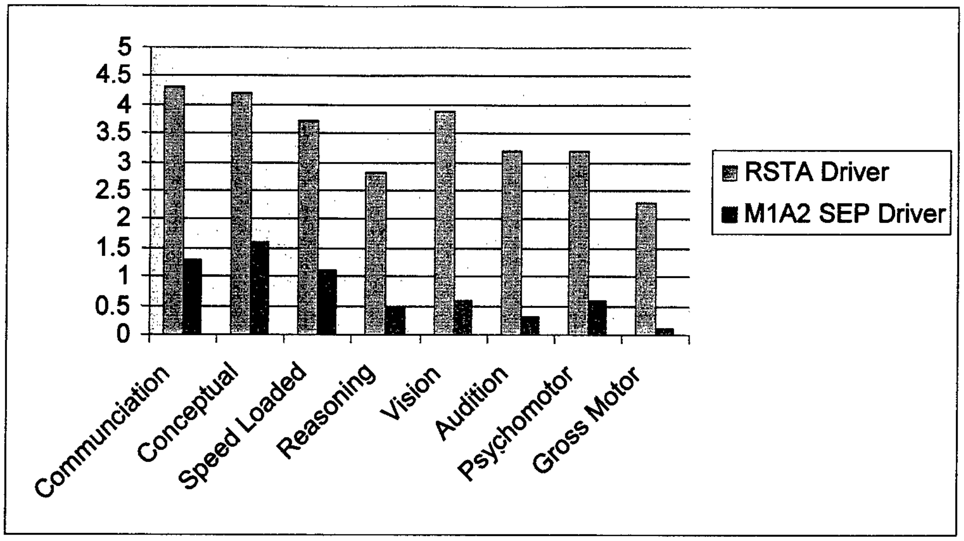

Figure 4. Cluster percentages for RSTA and M1A2 vehicle drivers.

4. Discussion

Drivers appeared to indicate that higher levels of skills were required to maintain SU than did vehicle commanders, immediately after training and after "job experience". This was unexpected, since vehicle commanders, as OCU operators, were expected to have the more demanding job. However, it appears that with such responsibilities as driving the vehicle, maintaining one's overall orientation on the battlefield, being responsible for vehicle self-defense, and assisting the commander in controlling robots, maintaining SU is even more demanding in terms of human abilities than maintaining SU while one is more or less exclusively operating robots.

Interestingly, while the rated level of abilities required for maintaining SU stayed essentially the same for drivers from training to job experience, the rated level of abilities declined for vehicle commanders. This suggests that while the training for drivers matched job experience (in terms of ability demands), training for vehicle commanders exceeded job experience in terms of skill demands. Put another way, commanders' reliance on certain skills to maintain SU declined from the first exercise compared to immediately after training, but drivers' reliance on the skills remained constant from training through the first exercise.

The highest rated skill clusters for "maintain SU" for vehicle commanders and drivers are "conceptual," "communication," "vision," and "speed loaded." That these clusters are important seems to make sense. The cluster "conceptual" involves such skills as flexibility of closure (the ability to detect a known pattern), visualization (the ability to predict how a pattern will appear after changes are made), problem sensitivity (the ability to tell when something is wrong or likely to go wrong), and spatial orientation (the ability to tell where you are in relation to the location of some object or vice versa). Communication is also critical in maintaining SU. Providing information to or acquiring information from others is critical in verifying or rejecting hypotheses about the situation. The cluster "speed loaded" involves such skills as speed of closure (combining different pieces of information into a meaningful pattern quickly), perceptual speed and accuracy (comparing patterns quickly), time sharing (shifting back and forth between sources of information, such as different screens or human versus computer input). Visual skills involve near vision, color discrimination and glare sensitivity. These skills would be useful in identifying entities represented on the screen—the first step toward pattern recognition and SU.

Drivers would need these skills, for example, to detect from the SC4 and communications traffic that a group of nearby icons represented a threat, to advise the vehicle commander of the threat, and to understand where the vehicle could be positioned to avoid the threat while continuing the mission. These skills would be useful to a vehicle commander, for instance, in determining that the group of wheeled vehicles to the north could be trucks that could arrive in the nearby village within a half hour, which would be bad if they were enemy, and further, that one's unmanned aerial vehicle is close enough to provide confirmation before the vehicles reach the village.

One should also note that while "psychomotor" skills played only a minor role and "auditory" and "gross motor" clusters no role at all, these vehicles were situated on a concrete floor and "moving" only across virtual terrain. If the commander and driver had been in a real vehicle, pitching over the terrain with gears grinding and engine howling, auditory and gross motor clusters may well have played some role, and psychomotor skills an even greater role.

Also, the cluster "reasoning" did not rank highly for any task. However, the skills involved in this cluster were defined in mathematical terms (e.g., inductive and deductive reasoning, number facility) rather than the more general use of this term.

Concerning comparison of RSTA crews with M1A2 SEP crews, skill requirements in general were higher for RSTA crews. RSTA commanders had substantially greater skill requirements for communication, vision, and audition. Since the RSTA commanders had a much wider area of responsibility than would tank commanders, it seems to make sense that obtaining and providing information related to maintaining SU would be more difficult for them than for tank commanders. However, considering that the RSTA commanders were in a simulation, the higher skill requirements for vision and audition are more surprising. Apparently, it is more difficult (vision-wise) to maintain SU by observing several screens in an RSTA vehicle than to maintain SU by observing a Force XXI Battle Command at Brigade and Below screen and the external environment in a tank. Also, we observed that RSTA commanders frequently communicated with RSTA drivers, as well as with unit of action personnel outside the vehicle, perhaps increasing the audition skill requirements over those of a tank commander. For the RSTA drivers, overall skill requirements were higher. On the cognitive skill clusters, perhaps this would be expected, since tank drivers have a much smaller area in which they must maintain SU, as well as no gunnery duties. However, considering that M1A2 SEP drivers were in field environment, their physical skill requirements might be expected to be higher. Thus, the differences on these skills could well be magnified if the RSTA drivers were in a field environment.

There are some limitations of this research. Since the scenarios were not controlled (at least at vehicle level), it is possible that the scenarios were inadvertently more demanding for drivers than for vehicle commanders. Demographics show that commanders tended to be of higher rank, better educated (more college graduates), and had more time in the National Guard. Thus, the commanders' greater experience and education could have made their job seem easier. It is difficult to assess how much of differences in skill ratings are attributable to differences in experience versus differences in the job. Also, had the second administration been conducted later, as originally scheduled, the drivers' ratings may have decreased because of more experience. Of course, these results are based on simulation versus a field environment.

5. Recommendations

The important skill clusters for OCU personnel appear to be "conceptual," "communication," "vision," and "speed loaded." One strategy to improve performance of these skill clusters is human factors engineering (HFE). HFE could be used to improve conceptual skills by providing decision aids in pattern recognition. Subject matter expert input could be used to identify recurring, important patterns. Then, when a pattern is located by the software, commanders and drivers could be cued to its presence, for instance, "enemy air defense units located on aerial sensor route," or "threat vehicle near direct fire range." In order to help improve vision, optimizing human factors design seems to be advisable. For instance, icons should be designed to be easily recognizable as representing a specific entity, and the software should allow for rapidly "zooming" in and out of views. Communication skills could be facilitated by "chat room"-type software, making it easy for key players on a specific task to communicate easily without having to depend on line-of-sight radios. One way to improve quick pattern fusion (i.e., speed-loaded skills) would be to have a true common display that shows all information, rather than our having to look at several screens to combine information. The "chat" channel could even be at the bottom of the screen.

For the "concept," "communication," and "speed load" clusters, specifically designed training seems to be important. High-paced scenarios involving multiple tasks, when personnel must combine information from several sources in order to recognize patterns and problems while maintaining their individual spatial orientation, would probably be beneficial. One example of this would be, while directed to move one set of robotic vehicles to cover a bridge, personnel are alerted to multiple vehicles approaching a village. The commander and driver must then determine if the vehicles represent, for instance, an enemy force, coalition vehicles "out of position" or a Red Cross convoy bringing aid.

Personnel selection or assignment might also play a role. While personnel could be screened for any of these skills, color vision seems to be among skills that are difficult or impossible to teach and are therefore good candidates for selection.

As was mentioned, no written job responsibilities for vehicle commanders and drivers were provided. More research is needed during more controlled conditions to determine the optimum division of duties between the commander and driver at various stages of mission progression and the effects of such distributions on abilities needed and task performance.

Abilities for future jobs, such as RSTA vehicle commander and driver may be different than abilities required for present-day equivalent positions, such as scouts. Although no scout data were available, a comparison with high technology tank crews suggests that more abilities may be required for future jobs. It is important that the determination of abilities and the level of abilities that may be needed for future jobs be done empirically, versus using someone's best guess. This report demonstrates one method of empirical research into the abilities required for future jobs before the materiel to perform those jobs has been fielded.

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