ARMY RESEARCH LABORATORY

Crew Characteristics for Common Ground Station Applications

John D. Warner
Beverly G. Knapp

ARL-TN-162 MAY 2000

Windows™ is a trademark of Microsoft Corporation.

Abstract

The purpose of this study was to determine the required skill set for common ground station of the future (CGS-future) and compare it to the present military occupational specialty (MOS) 96H skill requirements in order to determine the appropriateness of the 96H for operating the CGS-future. We approached the objectives by conducting subject matter expert and documentation reviews of presently accepted training for MOSs 96H, 96D, and 96B; by employing the Job Assessment Software System (JASS) in order to assess what skills and abilities are needed for what duty and at what demand; and by creating a dynamic task-network performance model to simulate work flow and error rate during different operating conditions. Results indicated that there is skill shift (higher levels of analytical skills required) for the operator of the CGS-future. These skill demands are at a level similar to or higher than those required by MOSs 96D and 96B. However, a simple substitution of the more analytically trained MOSs (96B and 96D) is not the solution, since the training cost to learn CGS skills exceeds the cost to enhance current training. The cost-effective approach would be to determine what 96B and 96D skills and how much of them must be integrated into the 96H training. Furthermore, the complex relationship of the training to successful performance, especially under different mission demands, is not validated. Further use of the dynamic model to develop a body of data derived from careful manipulation of personnel mixes and mission requirements could provide valuable advice to decision makers who track these complex issues.

ACKNOWLEDGMENTS

The authors wish to express their gratitude to several groups and key individuals who provided subject matter expertise and participants for this study, and without whom the effort would not have been possible. First, for initiating and sponsoring the effort, Mr. Mike Powell, Director, Futures, U.S. Army Intelligence Center and Fort Huachuca (USAIC&FH), Arizona. Next, the entire Training and Doctrine Command, System Manager–Joint Surveillance Target Attack Radar System, Common Ground Station Office, especially COL Michael Gourgues, CPT Ray Pickering, Mr. Chris Friend, and Mr. Bryan Wukits.

Also invaluable were the 96H training, testing, and new system development cadre at USAIC&FH, Fort Huachuca, in particular, SFC Connelly, SSG Kroona, SSG Baker (B Company, 309th Battalion), SFC Palenik (Intelligence Electronic Warfare Test Directorate), and 1LT Young (New Systems Training Office).

In the field, sincere appreciation to the Commander, 525th Military Intelligence Brigade, Fort Bragg, North Carolina, COL Richard Zahner; Commander, B Company, 319th Military Intelligence Battalion, MAJ Piper, and all the 96H operators in B Company who provided data for the study and important insight into military intelligence issues for future sensor operators. .

Finally, our thanks to (recently retired) military subject matter experts and system engineers at the Motorola contractor site, especially Ms Pam Roose, Mr. Dennis Dienes, Mr. Jim Miller, and Mr. Chuck Roose, who provided the vision of the future common ground station system.

TABLE OF CONTENTS

TABLES

CREW CHARACTERISTICS FOR COMMON
GROUND STATION APPLICATIONS

1. Introduction

The common ground station of the future (CGS-future) is a multi-sensor hardware and software system currently being developed, whose purpose is to provide near real-time intelligence via a moving target indicator, synthetic aperture radar, still images, unmanned aerial vehicle images, and signal intelligence sources, (e.g., intelligence electronic warfare common sensor [IEWCS] and ground-based common sensor [GBCS]). The CGS-future is expected to greatly increase support to tactical commanders who must quickly see the immediate battle space picture and manage resources in order to perform their assigned missions in a timely manner. With the enhanced imaging and entity-tracking technology associated with the CGS comes the potential for new information-processing task demands for the current 96H imagery ground station operators. The intelligence community has raised a question regarding the match of the current military occupational specialty (MOS) 96H operator skill profile and the operator capability to perform critical mission functions with the new technology. The issue of immediate concern is the determination of the human performance (skills and abilities) requirements for the soldiers projected to operate this system and how these requirements match current MOS holders and baseline (predecessor) system operators.

2. Objective

The objective of this study, conducted by the U.S. Army Research Laboratory (ARL), Fort Huachuca Field Element, Arizona, for the Training and Doctrine Command (TRADOC) Systems Manager, Joint Surveillance Target Attack System, Common Ground Station (TSM JSTARS/CGS), was to determine the required skill set for CGS-future and compare it to the present 96H skill requirements. In addition, we looked at the skill requirements for other MOSs whose skills might be relevant to the CGS in future operations. The key question concerned the performance impacts of alternate crew (MOS) configurations in CGS-future. Stated more directly, "Is the 96H still the right MOS for the new CGS versions to be deployed in the future?"

To accomplish the study objective, we quantified and compared the skills and abilities requirements for the current MOS, baseline (current) systems, and future JSTARS-CGS system operators using the Job Assessment Software System (JASS). We also assessed the implications and impacts of these skill and ability demands on performance and training level requirements by constructing and executing a dynamic task-performance simulation model.

3. Method

The analytical approach consisted of several phases:

1. Review recently available documentation about CGS positions and 96H tasks, including training documentation.

2. Interview key personnel (subject matter experts [SMEs]) who have experience with imagery collector systems (JSTARS and CGS). The study included people with experience with current systems, people training in current systems, and those involved with future system development.

3. Using JASS, collect job assessment data (skill-ability demands) from personnel who were MOS operators in current systems and were SMEs for ensuing systems.

4. Develop a dynamic task-performance simulation model to allow an analysis of performance impacts during different scenario and tasking conditions that produce different levels of demand with various MOS crew configurations.

5. Combine obtained data into a presentation format that will show key findings and implications regarding the questions raised.

3.1 Documentation Sources and Key Personnel

Sources of documentation for the 96H MOS included 96H critical task lists (current, initial operational test and evaluation [IOT&E], Task Force XXI), 96H, 96D, and 96U "Crosswalk," 96H course schedules, 96H selection criteria (Department of the Army, 1990), and 96H "cradle-to-grave" briefings.

In addition, because we wanted to look at other MOSs that might have useful skills for the CGS-future, we used the following sources of documentation for the 96B and 96D MOSs: 96B Total Army training system (TATS) program of instruction (POI) (not approved), 96B course management plan, 96D POI, 96D and 96B entry qualification standards, and the 96D future POI.

Using this documentation, we compiled a list of high level functions and presented it to key personnel to obtain feedback and consensus about thorough representation of critical 96H, CGS, 96D, and 96B functions.

The seven high level functions that were agreed upon as representative of the full range of current 96H or future tasks in a CGS mission are defined in Table 1. These functions formed the basis for structuring tasks in the JASS assessment phase and evaluating tasks during various scenario conditions by using the dynamic simulation. The functions for the 96B and 96D MOSs had been determined in a concurrent study (Barnes, Knapp, Tillman, Walters, & Velicki, 1999) but were reconfirmed through the same process of current document review and SME input. These functions are summarized in Table 2.

Table 1

Seven High Level Functions for 96H and CGS-Future

1. **Establish COMM Links**: Establish and maintain communications (links and windows) with all-source analysis system (ASAS), fire support, unmanned aerial vehicle (UAV), satellite communication (SATCOM), E-8 aircraft, commander's tactical terminal (CTT); includes setting up databases, preparing map overlays, establishing radio nets and digital links.

2. **Display MTI-Track Targets**: Display, manipulate, and manage JSTARS moving target indicator (MTI) data in order to track targets and prepare collected data for later processing, analysis, and interpretation; includes bringing up data on workstation displays and altering, enhancing, zooming, and configuring imagery for exploitation.

3. **Respond to ASAS (MI[a] Unit) Tasking**: Respond to ASAS requirements to detect, identify, and report target information—collecting locations, activities, patterns, trends, etc.

4. **Respond to Fire Support Tasking**: Respond to fire support requirements to rapidly detect, identify, and report precision target information.

5. **Correlate UAV, CTT, MTI**: Correlate (compare, associate, and contrast) separate sensor data from two or more sources, such as UAV data with JSTARS MTI, CTT data with JSTARS MTI, UAV, and CTT data with JSTARS MTI, in order to identify relationships between entities.

6. **Perform Target Analysis**: Using correlated data, rapidly compile interpreted data for a target of opportunity.

7. **Use Intel-Ops Knowledge**: Integrate intelligence, intelligence preparation of the battlefield (IPB) and operations knowledge with collected and correlated data to determine the importance, significance, function, and capabilities of battlefield entities to support accomplishment of baseline tasking.

[a]military intelligence

Table 2

Nine Higher Level Functions for the 96B and 96D MOSs

96B functions	96D functions
1. Determine information gaps	1. Determine map positioning from imagery
2. Develop the situation map	2. Determine object dimensions on imagery
3. Develop an intelligence briefing	3. Prepare an imagery interpretation report
4. Develop a situation template	4. Identify equipment types on imagery
5. Develop a doctrinal template	5. Analyze installations on imagery
6. Identify high payoff targets	6. Analyze roads and railways on imagery
7. Predict potential military operations	7. Identify defensive measures on imagery
8. Perform interactive input processing	8. Detect battle damage on imagery
9. Assess incoming information	9. Analyze order of battle activity on imagery

3.2 Job Assessment Software System

JASS is a software-based research method for assessing skill and ability demands of new or existing jobs. It is based on more than 30 years of research by Dr. Edwin Fleishman and associates (e.g., Fleishman & Quaintance, 1984) and was first prototyped by ARL at Fort Huachuca in a pencil-and-paper version called the job comparison and analysis tool (JCAT) (Muckler, Seven, & Akman, 1990; Akman, Seven, Muckler, & Steinbach, 1991). A key to developing this method was the selection and tailoring of the skills and abilities taxonomy which would be comprehensive for jobs in applied information-processing domains and adaptable for military use. This taxonomy (Fleishman & Quaintance, 1984) consists of 50 defined, measurable skills and abilities dimensions which are further grouped into eight skill-ability groups or "clusters," as shown in Figure 1. The individual skills and abilities are defined in Appendix A.

JASS is currently implemented as a Windows 95™ program that presents a series of questions and scales for each task, job, or function. The SME is interviewed by the software which is organized in a flowchart style. First, SMEs are asked for a given function, if a particular skill is used. (Figure 2 is an example of the JASS flow.) If the answer is "no," the program asks about the next skill. If the answer is "yes," the SME is presented with a 7-point rating scale (1 very low; 7 very high) and is asked to use the scale to indicate how much of that skill is required. Each scale includes behaviorally described anchors at low, medium, and high points in the scale to help the SMEs determine how to apply the scale. The software collects the data for all jobs and skills and summarizes the data (mean scale values and standard deviations for each skill) for all participants. Using these data, the researcher can assess what skills are needed at what level and for what job functions.

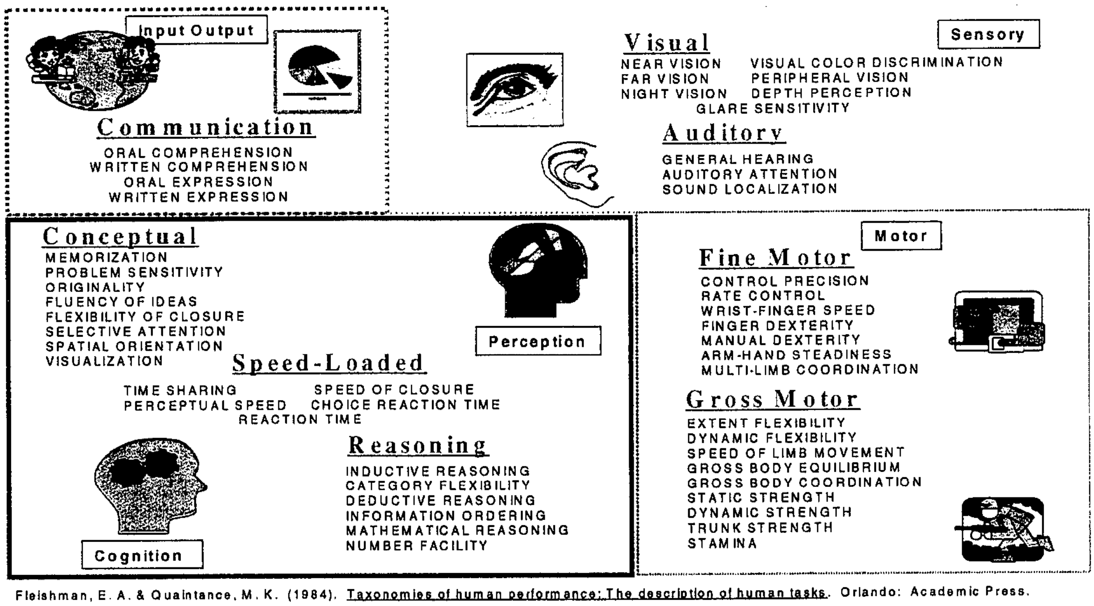

Figure 1. Fleishman-based 50 skills and abilities.

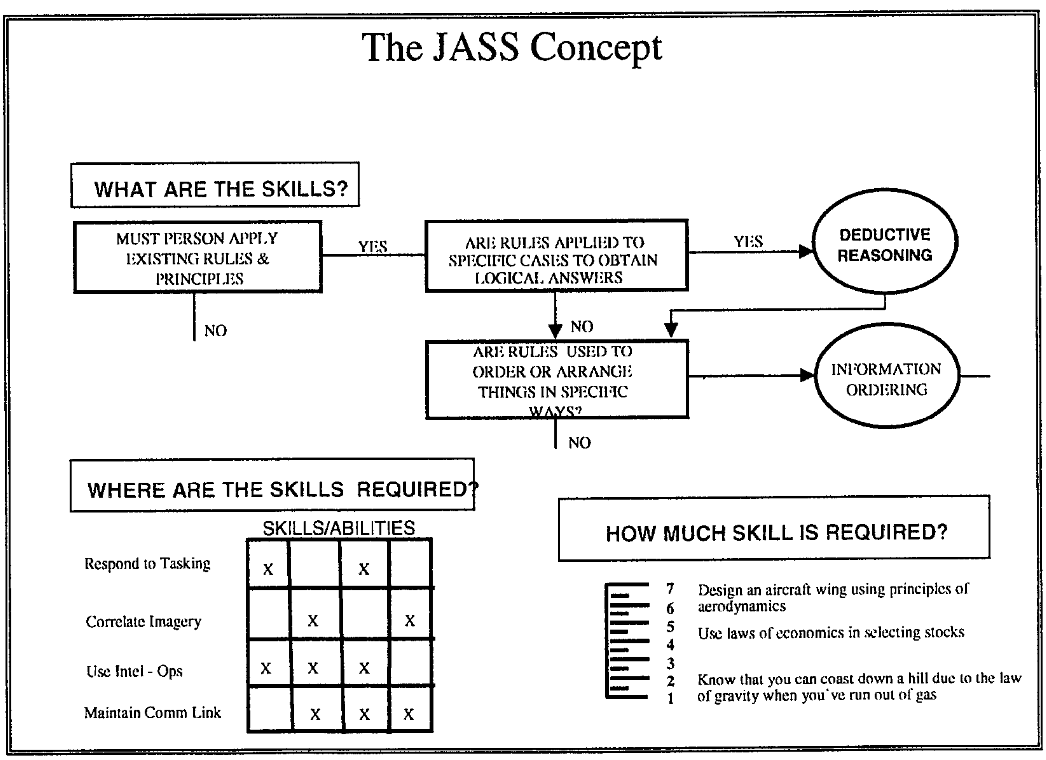

Figure 2. Example of JASS logical flow.

3.3 Dynamic Task-Performance Simulation Model

Dynamic task-performance simulation modeling is a technique for simulating the dynamic execution of soldier and machine tasks performed in an activity or system. It allows a person to alter the conditions in which the system tasks are performed (i.e., you can address "what if" questions) and to observe the differences in a number of time-based and performance-based variables in a far less costly way than field testing the actual system.

The model uses a network flow diagram (see Figure 3), the top level of which corresponds to the set of CGS functions. This flow diagram indicates the basic sequence of tasks performed by the system as a whole and includes alternate paths for task performance, given different "trigger" events. External events such as requests for information (RIs) trigger the execution of tasks, distribution of tasks to operators, and starting points in the network. Each task is assigned a distribution of execution times. Computer code determines the path through the network using predetermined task flow rules (times and rules derived from live performance databases and SMEs) in order to mimic realistic human behavior. The system clock keeps track of simulated time and task performance and can represent the current "state" of the system at any point in time.

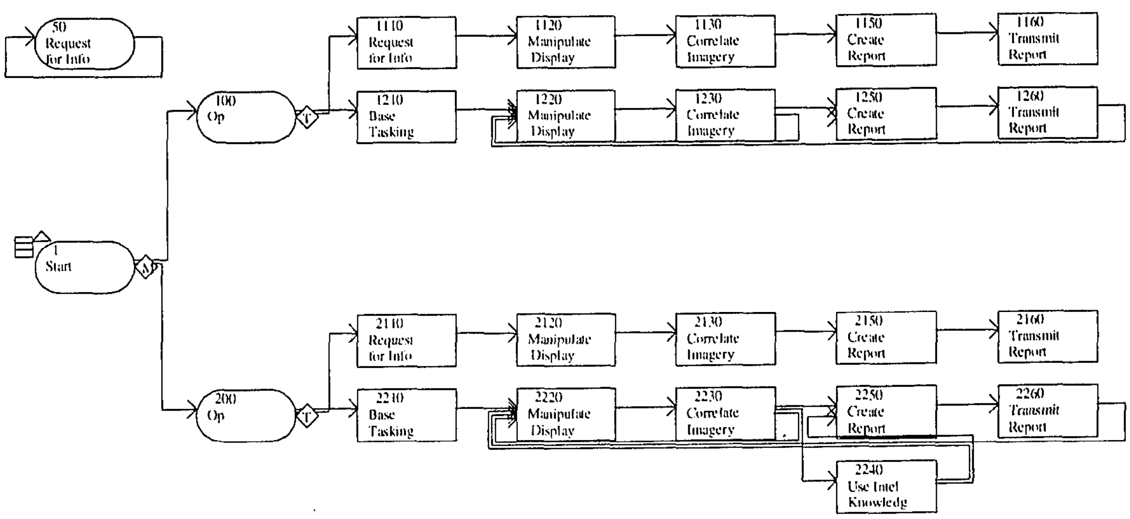

Figure 3. Network flow diagram (top level network only) developed for the CGS dynamic task-performance simulation model.

For the current study, we set up the model in order to examine the impact of

1. Crew composition (two operators—a 96H paired with another 96H, a 96B, or a 96D).

2. Different task allocation schemes (RIs and base tasking responsibilities).

3. Different RI and baseline tasking frequencies on task performance.

4. Results

4.1 Review of Documentation Sources

One important finding emerged from the review of documentation sources for the different MOSs (96H, 96D, and 96B). There are very clear and specific differences in how each of these MOSs is trained, in the number of hours, but more importantly in terms of distribution of military intelligence (MI) and non-MI content as well as the percent of time devoted to specific content areas or blocks. These differences are summarized in Table 3.

Table 3

Comparison of Distribution of Training Blocks for 96H, 96D, and 96B MOSs

Blocks of instruction	96H CGS (hours)	96H CGS (percent)	96D imagery (hours)	96D imagery (percent)	96B analyst (hours)	96B analyst (percent)
1. Map reading	24	3.50	50	7.40	23.5	4.14
2. Visible imagery	32	4.60	29	4.30	0.0	0.00
3. Radar	13	1.90	26	3.80	0.0	0.00
4. Infrared	0	0.00	10	1.50	0.0	0.00
5. Equipment ID	32	4.60	176	26.00	0.0	0.00
6. Lines of communication	5	0.70	36	5.30	0.0	0.00
7. Installations	0	0.00	24	3.50	0.0	0.00
8. Bomb damage assessment	7	1.00	33	4.90	0.0	0.00
9. Order of battle reports ASAS	15	2.20	41	6.00	112.5	19.80
10. Intelligent preparation of the battlefield	115	16.60	24	3.50	152.0	26.80
11. Collection management	5	0.70	8	1.20	66.0	11.60
12. Targeting	24	3.50	8	1.20	0.0	0.00
13. Briefing	7	1.00	3	0.44	65.6	11.60
14. Non-MI content	414	59.70	209	30.90	147.5	26.00
Total instruction	*693*		*677*		*567.0*	

One difference that seems to leap out is the amount of non-MI content in the training. The 96H training includes about 60% non-MI content, compared to 31% for the 96D (imagery analyst) MOS and 26% for the 96B (intelligence analyst) MOS. Documents indicate that much of this non-MI content for the 96H MOS relates to the operation and simple maintenance of the system. The greater specialization of the 96D is also apparent (emphasis on identification of equipment from imagery [Blocks 2 through 7]—44.4% compared to 11.8% for 96H and 0% for 96B) as is that of the 96B (emphasis on order of battle and intelligence preparation of the battlefield [Blocks 9 and 10]—46.6% compared to 18.6% for 96H and 9.5% for 96D). (This is also reflected in the function lists used for the JASS testing.)

4.2 JASS Findings

The purpose of the JASS analysis was to understand how both skill demands might change with the new system and how to evaluate the suitability of various MOSs to meet those demands. Three groups of SMEs were given the JASS tool to determine the skill and ability demands for each of the 96H CGS functions in Table 1. One group (n = 17) were 96Hs from the instructor and developer cadre at Fort Huachuca. Another group (n = 11) of 96Hs were operators in the field (B Company, 319th MI Battalion, 525th MI Brigade) stationed at Fort Bragg, North Carolina. The final group (n = 13), referred to as "CGS-future," were current and recently retired military SMEs from the system developer and contractor site. Figure 4 shows the system experience profile for each of these groups. In addition, we reviewed previously collected JASS data from SMEs for the 96B and 96D MOS, which were collected a few months earlier. Although these data were collected by using slightly different operator functions, which precluded direct comparison to the current 96H MOS data, the data can be used to make a gross comparison of the differences in skill and ability demands of each MOS overall.

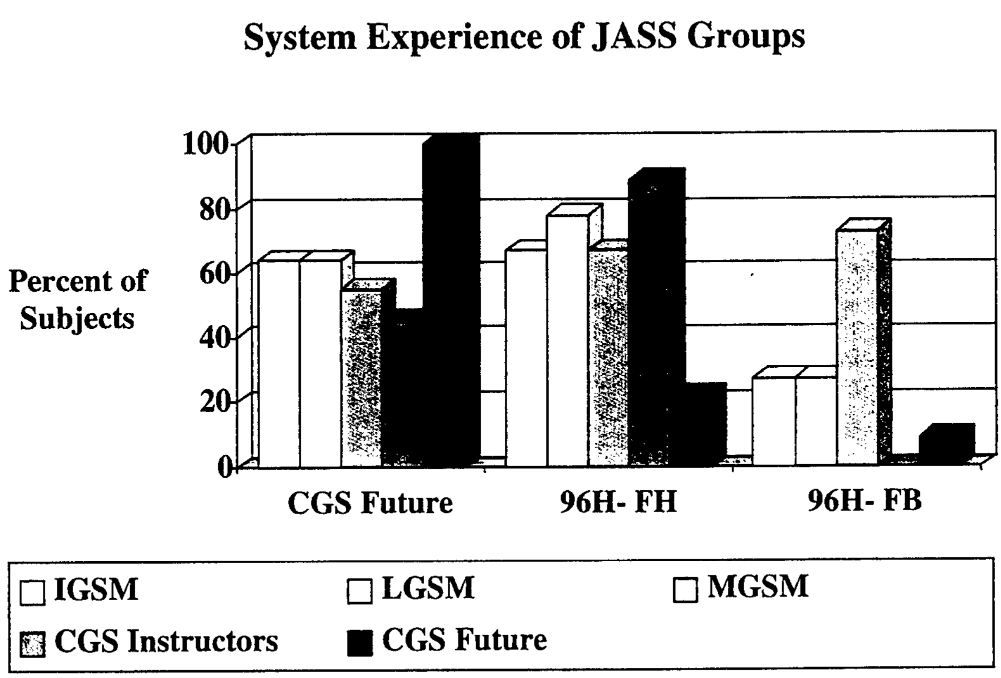

Figure 4. System experience of each of the 96H MOS groups.

JASS scores indicating the level of each skill and ability (0 to 7; 0 = no demand, 7 = extremely demanding) required for each function were averaged for all the participants. When averaged, scores higher than 5 are rare, so a score of 4 or greater (of 7) can be fairly interpreted as "very high demand" and a score of 3 as "high demand." While the number of high demand skills (>3) does not seem to change when the CGS-future group ratings (16 high demand skills) are compared to those of 96H instructors (15 high demand skills) and 96H field operators (15 high demand skills), there is a much more noticeable difference when comparing very high demand skills (>4). The CGS-future SMEs identified 10 very high demand skills as compared to 7 for the 96H instructors and 5 for the 96H field operators. This suggests that to perform the same 7 functions will require higher levels and numbers of skills in the CGS of the future.

Next, we looked at the data to compare the CGS-future SME responses to those of the other 96H SMEs. We chose to focus on the three cognitive-perceptual clusters of skills and abilities (conceptual, speed-loaded, and reasoning) as well as the communication cluster (see Figure 5). We did this because these are the skills and abilities that would be most impacted by changes in an intelligence system.

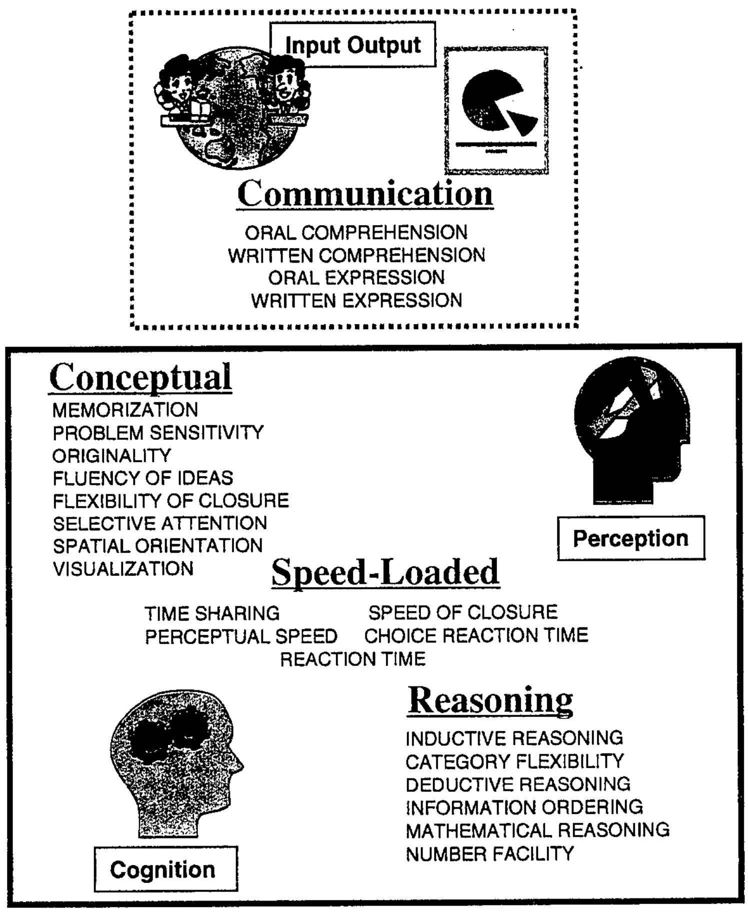

Figure 5. Fleishman skills and abilities isolating the cognitive-perceptual clusters.

The following patterns were found (see Table 4); (the complete data from this study are available upon request). Across all seven functions, communication skill demands decreased for the CGS-future, compared to how those functions are presently performed, indicating that the developers of the CGS addressed the need for increased efficiency in this area. For the other three skill clusters, there were differences between functions. For "display MTI-track targets," "respond to ASAS (MI unit) tasking," and "respond to fire support tasking," the predominant pattern was a reduction in skill demands for all clusters. However, for "establish COMM links," "correlate UAV, CTT, MTI," "perform target analysis," and "use intel-ops knowledge," there was a noticeable increase in skill demands in these other cognitive-perceptual clusters. This suggests that performing certain 96H functions will be more cognitively demanding in the future CGS as developed. When the functions that are impacted are examined, they are the functions that involve more analytical duties, suggesting that the CGS-future is requiring greater demand or need for imagery and possibly, intelligence analysis.

Looking at these same 23 cognitive-perceptual skills, we further compared the CGS and 96H SMEs for each of the 23 skills with the previously collected data from the 96B and 96D MOSs. We looked at what proportion of the functions (regardless of how differently they might be decomposed) for that MOS required a particular skill (average rating >3.0). These proportions are listed in Table 5. In addition, the gray shading in Table 5 indicates that at least one function demanded that skill at an average level of 4 or higher. Here, some of the higher demand skills for the CGS-future are supported at similar demand levels by the 96D and 96B profiles and they are under-represented in the current 96H profiles. Again, these are the skills that are required to handle more analytical functions.

4.3 Dynamic Task-Performance Simulation Model Results

Using the network model in Figure 3, we set up an experimental design to run the simulation multiple times to determine the effects on performance of manipulating three variables: crew configuration, RI frequency, and task allocation. The purpose was to explore the impact of using different MOSs and whether that impact changes during different working conditions.

4.3.1 Crew Configuration

If the CGS-future is going to require more intelligence and imagery analysis, it is reasonable to think there might be an advantage to having a 96B or 96D in the CGS. We established a two-operator crew in which one operator was always a 96H MOS but the other operator was a 96B, 96D, or another 96H.

4.3.2 RI Frequency

RI frequency ranged from 40 minutes between requests (standard deviation of 12 minutes) to 5 minutes between requests (standard deviation of 1.5 minutes). In all, six different RI frequency distributions were used in the simulation.

Table 4

Overview of Changes in Skill Demand Required by the CGS-Future for Each of the Seven Functions

Cluster	Skill↓ Function→	1	2	3	4	5	6	7
Communication								
	Oral comprehension	+	-	-	-	-	-	+
	Written comprehension	-	-	-	-	-	-	-
	Oral expression	-	-	-	-	-	-	-
	Written expression	-	-	-	-	-	-	-
Conceptual								
	Memorization	+	-	+	-	+	+	+
	Problem sensitivity	+	-	-	-	+	+	+
	Originality	+	-	-	-	+	+	+
	Fluency of ideas	+	+	+	+	+	+	+
	Flexibility of closure	+	+	+	+	+	+	+
	Selective attention	+	-	-	-	+	+	+
	Spatial orientation	+	+	-	-	+	+	+
	Visualization	+	-	-	-	+	+	+
Reasoning								
	Inductive reasoning	+	+	-	-	+	-	+
	Category flexibility	+	-	-	-	+	+	+
	Deductive reasoning	+	-	-	-	+	+	+
	Information ordering	+	+	-	-	+	+	+
	Mathematical reasoning	+	-	-	-	-	+	+
	Number facility	+	-	0	-	+	+	+
Speed loaded								
	Time sharing	+	+	-	-	+	+	+
	Speed of closure	+	-	+	-	+	+	+
	Perceptual speed and accuracy	+	-	-	-	+	+	+
	Reaction time	+	-	-	-	-	-	-
	Choice reaction time	+	-	-	-	-	-	-

+ = increased skill demand for CGS-future
- = reduced skill demand for CGS-future
0 = no change

Functions:
1. Establish COMM Links
2. Display MTI-Track targets
3. Respond to ASAS tasking
4. Respond to fire support tasking
5. Correlate UAV, CTT, MTI
6. Perform target analysis
7. Use intel-ops knowledge

Table 5

A Comparison for Each of the MOSs, Showing for the Cognitive-Perceptual Skills and Abilities (1-23), What Proportion of Functions Required That Skill
(Bold numbers indicate that at least one function required that skill at a demand level of 4 or higher.)

Skill name	Skill No.	CGS-future	96H FH	96H FB	96D	96B
Oral comprehension	1	**.57**	**.43**	**.43**	.89	**.89**
Written comprehension	2	**.43**	**.57**	**.57**	**1.00**	**1.00**
Oral expression	3	**.57**	.71	**.57**	**.67**	**.78**
Written expression	4	.29	**.71**	.43	**.33**	**1.00**
Memorization	5	**.71**	.86	.14	**.56**	**.56**
Problem sensitivity	6	**.43**	**.29**	.14	.22	**.56**
Originality	7	**.14**	.00	.00	.00	.11
Fluency of ideas	8	.29	.00	.00	.22	.00
Flexibility of closure	9	**.29**	.00	.43	.00	.22
Selective attention	10	.29	.57	.14	**.89**	**.78**
Spatial orientation	11	**.57**	**.29**	**1.00**	**.33**	**.33**
Visualization	12	**.43**	.14	.14	.11	.22
Inductive reasoning	13	.00	.14	.00	**.89**	**.44**
Category flexibility	14	.00	.00	.00	.44	.00
Deductive reasoning	15	.29	.14	**.43**	.33	**.33**
Information ordering	16	.29	.00	.00	.11	.00
Mathematical reasoning	17	.00	.00	.00	**.22**	.00
Number faculty	18	.00	.00	.00	.11	.00
Time sharing	19	**.57**	.43	**.14**	**.33**	.11
Speed of closure	20	.29	.14	.29	.00	.00
Perceptual speed and accuracy	21	**.29**	.29	.29	.33	.11
Reaction time	22	.00	.00	.00	.00	.00
Choice reaction time	23	.00	.14	.29	.00	.11

4.3.3 Task Allocation

Finally, we manipulated how tasks were allocated to the two operators. Each operator either did RI or base taskings only, or he or she each handled a mixture of base taskings while answering RIs. Work on base taskings was always second priority to satisfying RIs, regardless of task assignments. A key assumption in developing the model was there were no training deficiencies or outside stressors (fatigue, etc.) for any of the operators.

The output measures from each model run were

1. The number of base tasking reports not completed on time in relation to the total number of base taskings.

2. The total number of RIs processed in relation to total RIs in a scenario.

3. The number of RIs not completed within 10 minutes.

4. Time spent on preparing output report (used as a crude measure of report quality).

An example of output data from a series of model runs is shown in Table 6. (Note: These are sample data, to illustrate how the model works, and they show only one of the task allocation schemes.)

Multiple model runs (108) were made, counterbalancing all possible combinations of variables: crew, RI frequency, and task allocation. The output data from each model run were collected and analyzed. A review of the data tables showed that, while the model does a good job of capturing baseline CGS activity, the output variable settings used were not sensitive enough to capture significant differences in task performance as a result of operator MOS. The model showed, as expected, that more frenetic RI and base tasking frequency degrades performance, but it failed to show a striking benefit or liability for the various MOSs as represented in the model. Further model runs using a revised model that includes more detailed task decomposition and flow rules, a more realistic scenario input file, and more sophisticated output measures (such as a richer error scheme) should result in greater model sensitivity to operator performance differences.

5. Discussion and Conclusions

The clear, central finding of this study is there is "skill shift" toward greater demand for analytical skills in the CGS of the future. Specifically, the skill demands that will be increasing are those cognitive and perceptual skills that are required by the greater emphasis on intelligence and imagery analysis. A quick inspection of the training data and JASS skill profile data might lead to a recommendation for a simple substitution of one of the more analytically trained MOSs (96B and 96D) into the CGS crew, but there is a serious problem with this approach. The 96B and 96D MOSs would have to assume the rather large block of training with the CGS system equipment that the 96H currently receives. This would greatly inflate training time and be very costly. A more practical and cost-effective solution would be to add to the 96H training some of the more analytical blocks of content from the 96B and 96D training or to have experienced 96H personnel from basic and advanced noncommissioned officers' (BNCOC and ANCOC) courses, who receive more analytical training, become mandatory members of deployed crews. This would be a much smaller scale change, and the time and cost factor would be much more manageable.

Table 6

Sample of Summarized (hypothetical) Data from the Dynamic Task Performance Model

Task allocation	Crew configuration	RI frequency	Percent BT not in time	Percent RI processed	Percent RI not in time	Report quality RI	Report quality BT	Procedural errors	Processing errors
Op1:RI	96H	every 40 min.	20	100	0	1.00	1		
Op2: Base	96H	every 30 min.	20	100	0	1.00	1		
		every 20 min.	20	100	0	1.00	1		
		every 15 min.	20	99	1	0.99	1		X
		every 10 min.	19	95	5	0.94	1		X
		every 05 min.	19	93	7	0.62	1	X	X
	96H	every 40 min.	18	100	0	1.00	1		
	96B	every 30 min.	18	100	0	1.00	1		
		every 20 min.	18	100	0	1.00	1		
		every 15 min.	18	100	0	1.00	1		
		every 10 min.	18	99	1	0.99	1	X	
		every 05 min.	18	95	3	0.96	1	X	X
	96H	every 40 min.	19	100	0	1.00	1		
	96D	every 30 min.	19	100	0	1.00	1		
		every 20 min.	19	100	0	1.00	1		
		every 15 min.	19	98	2	0.99	1		
		every 10 min.	19	96	4	0.92	1		X
		every 05 min.	19	94	5	0.85	1	X	X

These are the data for all conditions for a single task allocation level.
RI = requests for information.
BT = base taskings.
The error columns simply indicate whether errors of that type occurred during the simulation.

Another problem in the simple substitution of MOSs is the fact that the complex relationship among training, experience, and task performance is not yet fully understood, nor can it be validated, especially in different mission types. The dynamic task-performance simulation model, if enhanced, could be used to capture these relationships and guide decision makers in better answering these questions. For example, how much and what type of analytical training needs to be added to the 96H course? Would it really be advantageous in some types of missions to employ a different MOS? What impact does the current training for the different MOSs have on the types of errors that are made? The dynamic model would allow trade-off studies to be conducted to answer these questions.

One of the keys to enhancing the model is to refine how specific errors affect the quality of the reports being produced. In the present model, error impacts are represented very simplistically. That is, 96H operators take less time than 96B or 96D operators to perform certain RI "procedural" tasks, and 96B and 96D operators provide better quality analytical reports for base tasking or "processing" tasks. These two broad categories of errors, procedural errors (e.g., failing to perform a required step during some task) and process errors (largely mental errors such as using outdated information), are not well represented in the current model, since only a single assumption is being exercised—that shorter times degrade report quality because performing tasks too quickly results in increased errors (either procedural or process). This scheme proved too simplistic. The simulation showed that personnel will always take as much time as they have to produce the reports, and it was only under the most extreme RI or base tasking load (frequency of taskings) that any degradation of report quality occurred.

We are currently developing an improved error scheme that could be implemented in the model for future simulation studies. This revised error scheme is summarized in Figures 6 and 7.

First, looking at Figure 6, note that the original scheme for error types has become much more detailed. Both procedural and process errors have been decomposed into five subtypes, depending on what sort of task activity is occurring (mental or physical). In addition, a further classification is made to distinguish between errors of commission (something was done incorrectly) and errors of omission (something that should have been done that was not). This framework creates the opportunity to better tie together calculation of the relationship between specific errors and their impacts on performance and will result in a much higher fidelity simulation. This approach would be much better suited to answering the questions posed.

Another, broader question that has yet to be addressed is the impact of the CGS of the future on tactical operations center (TOC) skill demands. This also could be addressed by the number of operators modeled and their associated tasks.

For now, what is known is that if the 96H training is reviewed in order to incorporate the analytical skills that may be needed in the future CGS, future 96H graduates will be more effective operators. This would avoid substituting other MOSs into the crew.

In answer to the original question stated at the beginning—"Is the 96H MOS still the right operator for the CGS of the future?" —the study findings indicate "yes," with a caveat to enhance current training.

Error Taxonomy for CGS Crew

- Skill Requirements create potential for errors
- Personal, task, and environmental characteristics impact the probability that these errors will actually occur

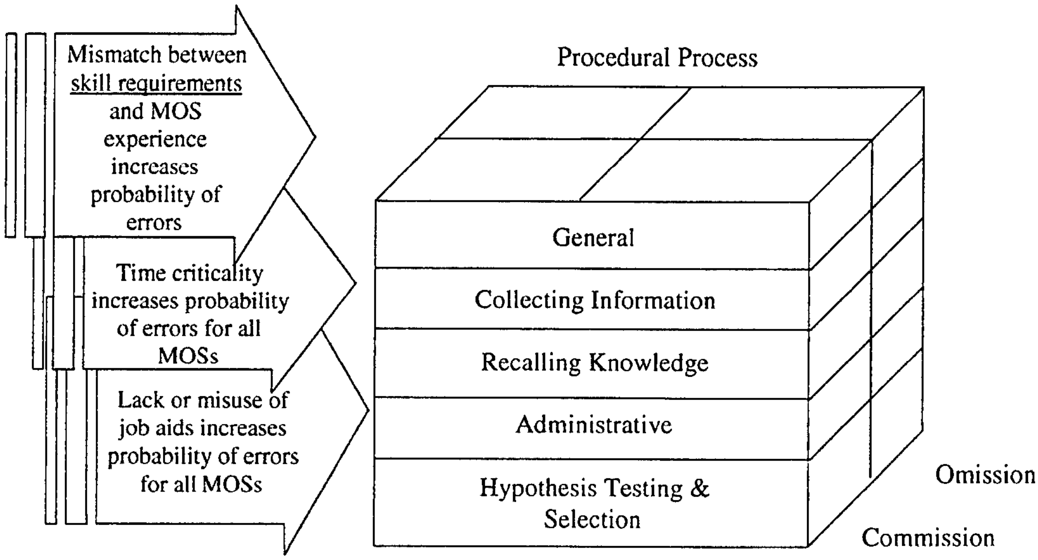

Figure 6. Error framework tying skill requirements and MOS to errors.

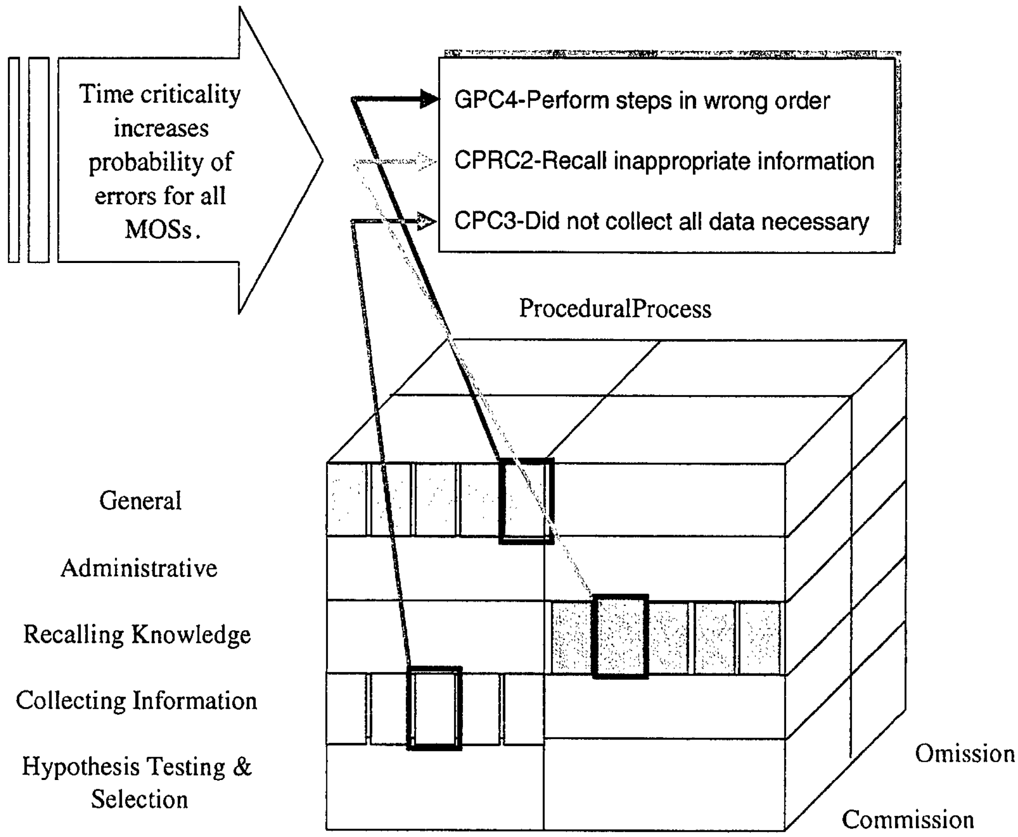

Figure 7. Example of the type of error profile that might be generated by the simulation.

References

Akman, A., Seven, S. A., Muckler, P. A., & Steinbach, C. (1991). The job comparison and analysis tool (JCAT): the abilities and skills dimension (JCAT-A) (Contract No. DAHC35-89-D-0028, DO 0004). Silver Spring, MD: Akman Associates, Inc.

Barnes, M.J., Knapp, B.G., Tillman, B., Walters, B., & Velicki, D. (1999). Crew systems analysis of unmanned aerial vehicle (UAV) future job and task environments. Manuscript in preparation.

Department of the Army (1990). Enlisted career management fields (CMF) and military occupational specialties (MOS) (AR 611-201). Washington, DC: Author.

Fleishman, E.A., & Quaintance, M.K. (1984). Taxonomies of human performance: The description of human tasks. Orlando: Academic Press.

Muckler, F.A., Seven, S.A., & Akman, A. (1990). Proposed method for military intelligence job assessment (ARI Research Note 90-135). Alexandria, VA: U.S. Army Research Institute.

APPENDIX A

DEFINITIONS FOR THE 50 SKILLS AND ABILITIES BASED ON FLEISHMAN AND QUAINTANCE, 1984

DEFINITIONS FOR THE 50 SKILLS AND ABILITIES BASED ON FLEISHMAN AND QUAINTANCE, 1984

Definitions as used in this study for each of the 50 skills and abilities measured by JASS are indicated next. Also indicated are the clusters to which each skill is associated. There are no specific definitions for the clusters, but it should be apparent what each cluster is about by the skills grouped under it.

Communication Skills

1. ORAL COMPREHENSION: The ability to listen to and understand words and sentences.

2. WRITTEN COMPREHENSION: The ability to understand written words, sentences, and paragraphs.

3. ORAL EXPRESSION: The ability to use words or sentences in speaking so that others will understand.

4. WRITTEN EXPRESSION: The ability to use words or sentences in writing so that others will understand.

Conceptual Skills

5. MEMORIZATION: The ability to memorize and remember information, such as words, numbers, pictures, and procedures. Pieces of information can be remembered by themselves or with other pieces of information.

6. PROBLEM SENSITIVITY: The ability to tell when something is wrong or is likely to go wrong. It includes being able to identify the whole problem as well as the elements of the problem.

7. ORIGINALITY: The ability to produce unusual or clever ideas about a given topic or situation. It is the ability to invent creative solutions to problems or develop new procedures for situations in which standard procedures do not apply or are not working.

8. FLUENCY OF IDEAS: The ability to produce a number of ideas about a given topic.

9. FLEXIBILITY OF CLOSURE: The ability to identify or detect a known pattern (such as a figure, word, or object) that is hidden in other material. The task is to pick out the disguised pattern from the background material (pattern recognition).

10. SELECTIVE ATTENTION: The ability to concentrate on a task one is doing. This ability includes concentrating while performing boring tasks and not being distracted.

11. SPATIAL ORIENTATION: The ability to tell where you are in relation to the location of some object or to tell where the object is in relation to you.

12. VISUALIZATION: The ability to imagine how something will look when it is moved around or when its parts are moved or rearranged. It requires the forming of mental images of how patterns or objects should look after certain changes, such as unfolding or rotation. One has to predict how an object, set of objects, or pattern will appear after the changes are carried out.

Reasoning Skills

13. INDUCTIVE REASONING: The ability to combine separate pieces of information or specific answers to problems to form general rules or conclusions. It involves the ability to think of possible reasons for why things go together.

14. CATEGORY FLEXIBILITY: The ability to produce many rules so that each rule tells how to group a set of things in a different way. Each different group must contain at least two things from the original set of things.

15. DEDUCTIVE REASONING: The ability to apply general rules to specific problems to come up with logical answers. It involves deciding if an answer makes sense.

16. INFORMATION ORDERING: The ability to follow correctly a rule or set of rules to arrange things or actions in a certain order. The rule or set of rules used must be given. The things or actions to be put in order can include numbers, letters, words, pictures, procedures, sentences, and mathematical or logical operations.

17. MATHEMATICAL REASONING: The ability to understand and organize a problem and then select a mathematical method or formula to solve the problem. It encompasses reasoning through mathematical problems to determine appropriate operations that can be performed to solve problems. It also includes the understanding or structuring of mathematical problems. The actual manipulation of numbers is not included in this ability.

18. NUMBER FACILITY: Involves the degree to which adding, subtracting, multiplying, and dividing can be done quickly and correctly. These can be steps in other operations such as finding percentages and taking square roots.

Speed-Loaded Skills

19. TIME SHARING: The ability to shift back and forth between two or more sources of information.

20. SPEED OF CLOSURE: Involves the degree to which different pieces of information can be combined and organized into one meaningful pattern quickly. It is not known beforehand what the pattern will be. The material may be visual or auditory.

21. PERCEPTUAL SPEED AND ACCURACY: Involves the degree to which one can compare letters, numbers, objects, pictures, or patterns, quickly and accurately. The things to be compared may be presented at the same time or one after the other. This ability also includes comparing a presented object with a remembered object.

22. REACTION TIME: The ability to give one fast response to one signal (sound, light, picture) when it appears. This ability is concerned with the speed with which the movement can be started with the hand, foot, or other parts of the body.

23. CHOICE REACTION TIME: The ability to choose between two or more movements quickly and accurately when two or more different signals (lights, sounds, pictures) are given. The ability is concerned with the speed with which the right response can be started with the hand, foot, or other parts of the body.

Visual Skills

24. NEAR VISION: The capacity to see close environmental surroundings.

25. FAR VISION: The capacity to see distant environmental surroundings.

26. NIGHT VISION: The ability to see during low light conditions.

27. VISUAL COLOR DISCRIMINATION: The capacity to match or discriminate between colors. This capacity also includes detecting differences in color purity (saturation) and brightness (brilliance).

28. PERIPHERAL VISION: The ability to perceive objects or movements towards the edges of the visual field.

29. DEPTH PERCEPTION: The ability to distinguish which of several objects is more distant from or nearer to the observer, or to judge the distance of an object from the observer.

30. GLARE SENSITIVITY: The ability to see objects in the presence of glare or bright ambient lighting.

Auditory Skills

31. GENERAL HEARING: The ability to detect and to discriminate among sounds that vary over broad ranges of pitch or loudness.

32. AUDITORY ATTENTION: The ability to focus on a single source of auditory information in the presence of other distracting and irrelevant auditory stimuli.

33. SOUND LOCALIZATION: The ability to identify the direction from which an auditory stimulus originated relative to the observer.

Fine Motor Skills

34. CONTROL PRECISION: The ability to move controls of a machine or vehicle. This involves the degree to which these controls can be moved quickly and repeatedly to exact positions.

35. RATE CONTROL: The ability to adjust an equipment control in response to changes in the speed or direction of a continuously moving object or scene. The ability does not extend to situations in which the speed and direction of the object are perfectly predictable.

36. WRIST-FINGER SPEED: The ability to make fast, simple, repeated movements of the fingers, hands, and wrists. It involves little, if any, accuracy or eye-hand coordination.

37. FINGER DEXTERITY: The ability to make skillful, coordinated movements of the fingers of one or both hands and to grasp, place, or move small objects. This ability involves the degree to which these finger movements can be carried out quickly.

38. MANUAL DEXTERITY: The ability to make skillful coordinated movements of one hand, a hand together with its arm, or two hands to grasp, place, move, or assemble objects such as hand tools or blocks. This ability involves the degree to which these arm-hand movements can be carried out quickly. It does not involve moving machine or equipment controls such as levers.

39. ARM-HAND STEADINESS: The ability to keep the hand and arm steady. It includes steadiness while making an arm movement as well as while holding the arm and hand in one position. This ability does not involve strength or speed.

40. MULTI-LIMB COORDINATION: The ability to coordinate movements of two or more limbs (e.g., two legs or one leg and one arm), such as in moving equipment controls. Two or more limbs are in motion while the individual is sitting, standing, or lying down.

Gross Motor Skills

41. EXTENT FLEXIBILITY: The ability to bend, stretch, twist, or reach out with the body, arms or legs.

42. DYNAMIC FLEXIBILITY: The ability to bend, stretch, twist, or reach out with the body, arms, or legs, both quickly and repeatedly.

43. SPEED OF LIMB MOVEMENT: Involves the speed with which a single movement of the arms or legs can be made or repeated. This ability does not include accuracy, careful control, or coordination of movement.

44. GROSS BODY EQUILIBRIUM: The ability to keep or regain one's body balance or to stay upright when in an unstable position. This ability includes maintaining one's balance when changing direction while moving or standing motionless.

45. GROSS BODY COORDINATION: The ability to coordinate the movement of the arms, legs, and torso together in activities in which the whole body is in motion.

46. STATIC STRENGTH: The ability to use muscle force in order to lift, push, pull, or carry objects. It is the maximum force that one can exert for a brief period of time.

47. EXPLOSIVE STRENGTH: The ability to use short bursts of muscle force to propel oneself or an object. It requires gathering energy for bursts of muscle effort over a very short time period.

48. DYNAMIC STRENGTH: The ability of the muscles to exert force repeatedly or continuously over a long time period. This is the ability to support, hold up, or move the body's own weight or object repeatedly over time. It represents muscular endurance and emphasizes the resistance of the muscles to fatigue.

49. TRUNK STRENGTH: Involves the degree to which one's stomach and lower back muscles can support part of the body repeatedly or continuously over time. The ability involves the degree to which these trunk muscles do not fatigue when they are put under repeated or continuous strain.

50. STAMINA: The ability of the lungs and circulatory systems of the body to perform efficiently over long time periods. This is the ability to exert oneself physically without getting out of breath.

NO. OF COPIES	ORGANIZATION
1	ADMINISTRATOR DEFENSE TECHNICAL INFO CTR ATTN DTIC OCP 8725 JOHN J KINGMAN RD STE 0944 FT BELVOIR VA 22060-6218
1	DIRECTOR US ARMY RSCH LABORATORY ATTN AMSRL CS AS REC MGMT 2800 POWDER MILL RD ADELPHI MD 20783-1197
1	DIRECTOR US ARMY RSCH LABORATORY ATTN AMSRL CI LL TECH LIB 2800 POWDER MILL RD ADELPHI MD 207830-1197
1	DIRECTOR US ARMY RSCH LABORATORY ATTN AMSRL DD 2800 POWDER MILL RD ADELPHI MD 20783-1197
1	DIRECTOR US ARMY RSCH LABORATORY ATTN AMSRL D D R SMITH 2800 POWDER MILL RD ADELPHI MD 20783-1197
1	DIR FOR PERSONNEL TECHNOLOGIES DEPUTY CHIEF OF STAFF PERSONNEL 300 ARMY PENTAGON 2C733 WASHINGTON DC 20310-0300
1	CODE 1142PS OFFICE OF NAVAL RESEARCH 800 N QUINCY STREET ARLINGTON VA 22217-5000
1	COMMANDER US ARMY RESEARCH INSTITUTE ATTN PERI ZT (DR E M JOHNSON) 5001 EISENHOWER AVENUE ALEXANDRIA VA 22333-5600
1	DEPUTY COMMANDING GENERAL ATTN EXS (Q) MARINE CORPS RD&A COMMAND QUANTICO VA 22134

NO. OF COPIES	ORGANIZATION
1	HQ USATRADOC ATTN ATCD SP FORT MONROE VA 23651
1	COMMANDER USA AEROMEDICAL RSCH LAB ATTN LIBRARY FORT RUCKER AL 36362-5292
1	CHIEF ARMY RESEARCH INSTITUTE AVIATION R&D ACTIVITY ATTN PERI IR FORT RUCKER AL 36362-5354
1	ARI FIELD UNIT FORT KNOX BUILDING 2423 PERI IK FORT KNOX KY 40121-5620
1	COMMANDANT USA ARTY & MISSILE SCHOOL ATTN USAAMS TECH LIB FORT SILL OK 73503
1	GOVT PUBLICATIONS LIBRARY 409 WILSON M UNIVERSITY OF MINNESOTA MINNEAPOLIS MN 55455
1	HUMAN FACTORS ENG PROGRAM DEPT OF BIOMEDICAL ENG COLLEGE OF ENGINEERING & COMPUTER SCIENCE WRIGHT STATE UNIVERSITY DAYTON OH 45435
1	PROGRAM MANAGER RAH-66 ATTN SFAE AV BLDG 5300 SPARKMAN CTR REDSTONE ARSENAL AL 35898
1	DIRECTOR US ARMY AEROFLIGHT DYNAMICS MAIL STOP 239-9 NASA AMES RESEARCH CTR MOFFETT FIELD CA 94035-1000
1	MS DIANE UNGVARSKY HHC 2BDE 1AD UNIT 23704 APO AE 09034

NO. OF COPIES	ORGANIZATION
1	DR SEHCHANG HAH DEPT OF BEHAVIORAL SCIENCES & LEADERSHIP BUILDING 601 ROOM 281 US MILITARY ACADEMY WEST POINT NEW YORK 10996-1784
1	US ARMY RESEARCH INSTITUTE ATTN PERI IK (D L FINLEY) 2423 MORANDE STREET FORT KNOX KY 40121-5620
1	US MILITARY ACADEMY MATHEMATICAL SCIENCES CTR OF EXCELLENCE DEPT OF MATH SCIENCES ATTN MDN A MAJ M D PHILLIPS THAYER HALL WEST POINT NY 10996-1786
1	ARL HRED AVNC FLD ELEMENT ATTN AMSRL HR MJ (R ARMSTRONG) PO BOX 620716 BLDG 514 FT RUCKER AL 36362-0716
1	ARL HRED AMCOM FLD ELMNT ATTN AMSRL HR MI (D FRANCIS) BUILDING 5678 ROOM S13 REDSTONE ARSENAL AL 35898-5000
1	ARL HRED AMCOM FLD ELMNT ATTN AMSRL HR MO (T COOK) BLDG 5400 RM C242 REDSTONE ARS AL 35898-7290
1	ARL HRED USAADASCH FLD ELMNT ATTN AMSRL HR ME (K REYNOLDS) ATTN ATSA CD 5800 CARTER ROAD FORT BLISS TX 79916-3802
1	ARL HRED ARDEC FLD ELMNT ATTN AMSRL HR MG (R SPINE) BUILDING 333 PICATINNY ARSENAL NJ 07806-5000
1	ARL HRED ARMC FLD ELMNT ATTN AMSRL HR MH (C BIRD) BLDG 1002 ROOM 206B FT KNOX KY 40121

NO. OF COPIES	ORGANIZATION
1	ARL HRED CECOM FLD ELMNT ATTN AMSRL HR ML (J MARTIN) MYER CENTER RM 2D311 FT MONMOUTH NJ 07703-5630
1	ARL HRED FT BELVOIR FLD ELMNT ATTN AMSRL HR MK (P SCHOOL) 10170 BEACH ROAD ROOM 12 FORT BELVOIR VA 22060-5800
1	ARL HRED FT HOOD FLD ELMNT ATTN AMSRL HR MV HQ TEXCOM (E SMOOTZ) 91012 STATION AVE ROOM 111 FT HOOD TX 76544-5073
10	ARL HRED FT HUACHUCA FLD ELMNT ATTN AMSRL HR MY (B KNAPP) GREELY HALL (BLDG 61801 RM 2631) FT HUACHUCA AZ 85613-5000
1	ARL HRED FLW FLD ELMNT ATTN AMSRL HR MZ (A DAVISON)* 3200 ENGINEER LOOP STE 166 FT LEONARD WOOD MO 65473-8929
2	ARL HRED NATICK FIELD ELEMENT ATTN AMSRL HR MQ (M FLETCHER) ATTN SSCNC A (D SEARS) USASSCOM NRDEC BLDG 3 RM 140 NATICK MA 01760-5015
1	ARL HRED OPTEC FIELD ELEMENT ATTN AMSRL HR MR (M HOWELL) OPTEC CSTE OM PARK CENTER IV RM 1040 4501 FORD AVENUE ALEXANDRIA VA 22302-1458
1	ARL HRED SC&FG FLD ELMNT ATTN AMSRL HR MS (L BUCKALEW) SIGNAL TOWERS RM 303A FORT GORDON GA 30905-5233
1	ARL HRED STRICOM FLD ELMNT ATTN AMSRL HR MT (A GALBAVY) 12350 RESEARCH PARKWAY ORLANDO FL 32826-3276

NO. OF COPIES	ORGANIZATION
1	ARL HRED TACOM FLD ELMNT ATTN AMSRL HR MU (M SINGAPORE) BLDG 200A 2ND FLOOR WARREN MI 48397-5000
1	ARL HRED USAFAS FLD ELMNT ATTN AMSRL HR MF (L PIERCE) BLDG 3040 RM 220 FORT SILL OK 73503-5600
1	ARL HRED USAIC FIELD ELEMENT ATTN AMSRL HR MW (E REDDEN) BLDG 4 ROOM 332 FT BENNING GA 31905-5400
1	ARL HRED USASOC FLD ELMNT ATTN AMSRL HR MN (F MALKIN) HQ USASOC BLDG E2929 FORT BRAGG NC 28310-5000
1	ARL HRED HFID FIELD ELEMENT ATTN AMSRL HR MP A KARRASCH C/O BATTLE CMD BATTLE LAB 415 SHERMAN AVE UNIT 3 FT LEAVENWORTH KS 66027-2300
	ABERDEEN PROVING GROUND
2	DIRECTOR US ARMY RESEARCH LABORATORY ATTN AMSRL CI LP (TECH LIB) BLDG 305 APG AA
1	LIBRARY ARL BLDG 459 APG-AA
1	ARL HRED ECBC FIELD ELEMENT ATTN AMSRL HR MM (R MCMAHON) BLDG 459 APG-AA
	ABSTRACT ONLY
1	DIRECTOR US ARMY RESEARCH LABORATORY ATTN AMSRL CS EA TP TECH PUB BR 2800 POWDER MILL RD ADELPHI MD 20783-1197

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	May 2000	Final

4. TITLE AND SUBTITLE

Crew Characteristics for Common Ground Station Applications

5. FUNDING NUMBERS

AMS: 622716.H700011
PR: 1L161102B74A
PE: 6.11.02

6. AUTHOR(S)

Warner, J.D.; Knapp, B.G. (both of ARL)

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

U.S. Army Research Laboratory
Human Research & Engineering Directorate
Aberdeen Proving Ground, MD 21005-5425

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

U.S. Army Research Laboratory
Human Research & Engineering Directorate
Aberdeen Proving Ground, MD 21005-5425

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

ARL-TN-162

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

The purpose of this study was to determine the required skill set for common ground station of the future (CGS-future) and compare it to the present military occupational specialty (MOS) 96H skill requirements in order to determine the appropriateness of the 96H for operating the CGS-future. We approached the objectives by conducting subject matter expert and documentation reviews of presently accepted training for MOSs 96H, 96D, and 96B; by employing the Job Assessment Software System (JASS) in order to assess what skills and abilities are needed for what duty and at what demand; and by creating a dynamic task-network performance model to simulate work flow and error rate during different operating conditions. Results indicated that there is skill shift (higher levels of analytical skills required) for the operator of the CGS-future. These skill demands are at a level similar to or higher than those required by MOSs 96D and 96B. However, a simple substitution of the more analytically trained MOSs (96B and 96D) is not the solution, since the training cost to learn CGS skills exceeds the cost to enhance current training. The cost-effective approach would be to determine what 96B and 96D skills and how much of them must be integrated into the 96H training. Furthermore, the complex relationship of the training to successful performance, especially under different mission demands, is not validated. Further use of the dynamic model to develop a body of data derived from careful manipulation of personnel mixes and mission requirements could provide valuable advice to decision makers who track these complex issues.

14. SUBJECT TERMS

common ground station (CGS)	JASS	MOS
crew configurations	modeling and simulation	skill comparisons

15. NUMBER OF PAGES

40

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102