Army Research Laboratory (ARL)
Insight Report Notes

A Human Factors Evaluation of the Custom Tent Design used during the 1st Brigade Task Force Lanes Exercise

Fort Hood, Texas

Army Research Laboratory (ARL)
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ACKNOWLEDGEMENT

The authors would like to acknowledge the contributions of Ronald Carty, of the U.S. Army Research Laboratory, to the research of alternative tactical operations center (TOC) shelter concepts. Mr. Carty provided outstanding photographic support, including audio-visual videography and digital still images, of the various shelter concepts and operational procedures involved in their employment. These images were used as sources of data in analyzing physical and human factors aspects of prototype equipment and military personnel tasks related to the TOC shelter designs. In addition, Mr. Carty provided instrumentation and obtained light measurements for representative locations within the TOC shelters that were used for evaluating the alternative design concepts. Mr. Carty's contributions were made with a high level of professionalism and were invaluable in providing needed data for the study.

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EXECUTIVE SUMMARY

This paper summarizes insights developed during the 1st Brigade Task Force Lanes Exercise relative to the Custom Tent shelter used for the Combat Information Cell (CIC) of the 1st BCT Main CP. Through the TOC Summit venue, it was recognized that the currently fielded shelter system might be inadequate for future U.S. Army digitized TOCs. The commander of the Combined Arms Center (CAC) directed the TRADOC Analysis Center-Fort Leavenworth (TRAC-FLVN) to provide an analysis to inform the November 2000 committee's decision on the system to select for the U.S. Army's future division-level and brigade-level TOCs. Consequently, TRAC-FLVN requested ARL-HRED to provide a human factors evaluation of the Custom Tent Design to support TRAC-FLVN's overall analysis. This effort considered both the TOC layout and internal operations for personnel requirements, information flow, and current operations decision making. To fulfill this effort, ARL-HRED developed a survey instrument (see Appendix B) to assess human factors, battlefield management, staff collaboration, equipment modularity, mobility, and security issues.

Currently, the U.S. Army fields the Modular Command Post System (MCPS), formerly known as the Standard Integrated Command Post System-Extensions (SICPS-E), with its command post vehicles (CPVs). The MCPS consists of tents and bootwalls that connect the vehicles to the tents. Command Posts (CPs) at all echelons use this system to create a common workspace which allows commanders and staffs to perform C3 functions, fuse information, and the myriad of tasks required during military operations. Although the currently fielded MCPS allows for the establishment of a common workspace, it does not provide an open architecture within which staffs can better perform their functions. An open architecture allows for the uninterrupted view of CIC displays and unimpeded movement of personnel within the shelter.

Currently fielded systems are not adequate because of architectural support poles that break up the MCPS common workspace.

The objective of this study was to provide HF analyses regarding the Custom Tent Design as input to TRAC as the lead to inform the November 2000 decision committee on the form (platform or shelter) to select for the Army's future division-level and brigade-level TOCs. The scope of this analysis was on the Custom Tent shelter used for the Combat Information Cell (CIC) of a Battalion or Brigade Tactical Command Post.

Several major issues were considered for the improvement of TOC operations. They were concerned with the TOC's tactical mobility, execution of C2, interior environment, equipment and personnel arrangements, modularity, flexibility, and security. In addition, human factors considerations for the alternative TOC interior light levels and ambient noise were made.

Numerous manufacturers can provide custom-built tents. This study used two soft-walled, internal-framed custom tents built to user specifications by the Custom Canvas Manufacturing Company (Buffalo, NY). Because the shelter was built to user specifications, it was configurable for vehicle booting and expandable, limited only by the physical constraints of the framing system. Materials vary but are normally the same as those used in MCPS type systems. The manufacturers included flooring, ground covers, and repair material and equipment in addition to the actual tents.

Regarding tent installation, almost 64% percent of the staff that completed the survey felt that the Custom Tent design did not facilitated quick set up time. They felt that there were two many fasteners and wires. The Custom Tent set-up time was approximately 50 minutes per tent for the 1 BCT TOC. Extreme weather (e.g., wind, cold temperatures, & rain) and dark conditions increased the time as did the inexperience of all personnel who had only set up the

tent two previous times. Although the time required to set up and boot four MCPS systems was not observed during this exercise, NCO's stated that the Custom Tent could be established much more quickly than four booted MCPS systems. Even though an individual MCPs takes between 20-30 minutes to set up, connecting four MCPS systems together and assuring that the gutters are water tight will take longer. The custom tent which equalls in size to four MCPS has no gutters.

Regarding tent only disassembly, 54 % of the surveyed staff felt that the Custom Tent design did not facilitated quick tear down while 33% felt that it did. Fifty eight percent of the staff surveyed rated the Toc components as hindering mobility.

It was observed that the 1 BCT Main CP required approximately 4.5 hours to march order (i.e., disassemble and prepare all the TOC digital and non digital equipment and Custom Tent for movement). This time appears to be long but is explainable considering the unit's current lack of experience. This was the first time that this digitized unit had conducted a march order. As a training exercise it emphasized the need for a march order SOP and the need for some staff training, task prioritization, and rehearsal. Some of the extra time required to march order was consumed by the unit's using three heavy expanded mobility tactical trucks (HEMTTs) from the FSB and moving floor boards, sandbags miscellaneous TOC equipment and the breakdown and packing of the 9 panel digital display.

The 1st Brigade layout provided more than adequate space for CP equipment and personnel during military operations. Over 95% of the staff surveyed felt that the custom tent provided adequate space for equipment and 83.3 % felt that it provided adequate space for the number of personnel required for effective TOC operations. Most of the time there appeared to be unneeded room in the MCPS shelters attached to the 1st BCT Main CP Custom Tents. These

spaces were only used when TOC briefings were conducted. Possibly, the TOC with its attached vehicles could be reconfigured to eliminate the need for, at least, one of the two MCPSs used in this study.

The staffs' opinion on a quick establishment of an integrated LAN communication system was mixed. Only 37.5% of those surveyed rated the TOC system as facilitating a quick establishment while 41.7 % felt that it hindered a quick set up. The lack of an established and standardized TOC wiring diagram was felt strongly needed.. This brigade's 74B was working toward creating such a diagram.

The 1st Brigade Custom Tent with its open architecture configuration was regarded as facilitating the commander's ability to exercise C2 in the CIC to some degree. Eighty three percent of the staff felt that the design supported, facilitated or greatly facilitated the Commander's ability to provide direction and management. Almost 80% felt that the design allowed the Commander to maintain an active command presence among the entire staff. The commander had the ability to rearrange functional elements to meet METT-TC requirements. The commander had access to each member of the staff throughout the exercise and his command presence was in clear view of the entire staff. All the staff teams could easily see and hear the commander.

The personnel line of sight view of the situational map and information displays varied.as did the staffs' rating of the arrangement of equipment and personnel to facilitate access to information displays. This staff team working at the first row of tables had a clear view of the FBCB2 situational maps as well as the wall-mounted paper map with friendly and enemy updates and UAV information directly in front of them. The battle captain was able to supervise the efforts of the staff NCOs, conduct analyses and assessments of available information, assist

in the review and dissemination of information from the other BFAs, and assist in monitoring the location and activity of friendly units. The battle major monitored and updated the information displayed on the electronic display screens and paper maps. However, the staff in the back row of tables of the CIC had some problems viewing the map boards and large screen displays. One suggestion was that the rear tables should have one or two computer monitors to view the Common Operational Picture (COP). The majority of the ABCS platforms were housed in the C2Vs and the operators had a "caved mentality" with little access to the battle staff.

The Custom Tent was relatively watertight when compared to the MCPS. The larger size of the Custom Tent reduced the need for gutters at the connecting points which often leaked. Consequently, though it rained intensely for many hours, no significant water was observed to leak from the ceiling attachments involving the Custom Tent Designs. However, it was noted that some connector pin assembly parts had broken which were used to connect the roof sections of the tents. Therefore, it is recommended that the connector parts be ruggedized to withstand the battlefield environment. If possible, the connector parts should remain attached to appropriate tent sections, even when the tent sections themselves are not connected, so that the connector parts will be available when needed and not get misplaced during frequent TOC relocations.

Another problem associated with the interior TOC environment and rain is the mud that can result on the ground space under the tent area. Though the Custom Tent design included a tarpaulin floor it did not prevent water getting into the TOC ground space and causing severe mud development on the floor. The mud was sticky and built up on the shoes of the military personnel which slowed their performance. The mud severely hindered the TOC displacement

process as it took 8-10 soldiers an inordinate amount of time, ingenuity, and physical effort to manipulate and load the tarpaulin floor onto a truck.

Regarding safety, one potential TOC safety hazard that was noted involved personnel climbing on the Custom Tent to disassemble the camouflage netting. It was cumbersome and, perhaps, unsafe to climb on top of a tent that is 11 feet high and not intended to support the weight and movement of soldiers.

The soldiers were asked to rate the modularity of the Custom Tent design to allow for open TOC architecture to support the commander's layout preferences for the arrangement of equipment and personnel. Over 92% felt that it at least supported the Commanders layout preference. When asked to rate the adaptability of the TOC design to accommodate large screen displays and multiple displays, 83% of the soldiers rated the design as at least supported this type of display technology. Seventy five percent of the staff surveyed thought that the design permitted or enhanced the Commander's ability to observe the staff.

Eighty percent of the soldiers rated the flexibility and open architecture of this design as supporting the performance of tasks related to METT-T. In an interview, they stated that the ATCCS with the large screen displays allowed real time action for the commander and that the Jupiter gave the commander a versatile tool to manipulate and display data. It was also stated that this design provided an excellent ability to switch feeds from the various boxes through the DPV to display information on a large screen. The only negative comments were due to either power failure and equipment failure.

Only 45.8% of the soldiers rated the TOC system design able to support concealment and camouflage techniques while 50 % felt that the design hindered it. As confirmation, only 4.2% stated that it greatly facilitated. No light could be seen escaping from the TOCs at night. Fifty

percent of the staff surveyed felt that it would be hard to take measures to prevent observation and detection. The respondents stated that the size and height of the TOC layout and the noise level from the numerous vehicles and generators would cause the TOC to be an easy target. This problem exists regardless of the TOC configuration used.

When asked how the did this TOC design affect the ability to control thermal signature, only 25% felt that it could be controlled. The numerous vehicles and generators added to the thermal signature problem.

Only 41.7%% of the soldiers indicated that this TOC design aided the ability to control physical TOC evidence (signature). None of the respondents stated that this design greatly facilitated their ability to control the signature. Once again, the size of the TOC layout and the noise level from vehicles and generators made the TOC an easy target.

The sources of illumination in the 1st brigade TOC "A" were fluorescent work lights located at a height of approximately 7 feet. The TOC CIC operations using the Custom Tent design were conducted in incident light levels ranging from 8-16 foot-candles. These levels of illumination are adequate for normal detail but not for prolonged periods of reading printed material. The levels of illumination in the adjacent Custom Tent design (i.e., left-hand side of the TOC), which support the CIC, ranged from 4-16 foot-candles. At the right-hand side of the TOC was a currently fielded tent, the MCPS, which had light levels ranging from 2-12 foot-candles. The TOC areas which supported the CIC had lower light levels than the CIC but the requirement for prolonged periods of reading printed material was also less.

A TOC at another location (i.e., TOC "B") had its fluorescent work lights mounted in the upper 4-foot section of the Custom Tent design ceiling. Overall, the lighting levels in work areas for TOC B were lower than for TOC A. The lighting level at any given location appeared to be

most directly related to the distance from the light source. Consequently, the overall light levels in TOC B were lower than for TOC A.

The current 1st brigade TOC operations were conducted in average noise levels ranging from 67-78dB using the A weight and 79-83 dB using the C weight. This level of background noise was loud but did not exceed the steady state noise hazard requirement of 85 dB measured (using the A weight) as specified in Army Pam 40-501. The source of the loud background noise was due to the turbine engines of the C2V along with the primary power unit (PPU). The majority of the staff felt that they could not control the noise levels. The sound readings at the engine exhaust box were measured resulting in an average of 89 dB with the A weight and 92 dB with the C weight. Sound protection around these vehicles is required.

The majority of the staff surveyed felt that voice commands were easily heard throughout the TOC. The majority (75%) of the staff felt that the design promoted or at least supported efficient internal communication.

The consensus of the staff was that if the day and night shifts of the brigade or battalion staff were combined, then there was adequate manpower to set up or disassemble the CP that utilized the Custom Tent configuration. However, the majority of the staff (62.5%) surveyed expressed concern that there was not enough people to man the planning requirements of the TAC or complete all tasks that have increased because of digitization. As a consequence, TOC security was minimal.

Training and experience on the ABCS needs to be increased. Most of the staff was relatively new with only 2-3 months of experience. The TOC did have a couple of experienced ABCS staff members that could reconfigure and reactivate the ABCS workstations. However,

the ABCS operators had to complete other TOC duties and could not devote their full attention to ABCS.

No additional personal skill identifier (ASI) or MOS was felt to be required for set up or disassembly of the Custom Tent configuration. Guidance for battlefield functional area layout was received from the commanders in both the battalion and brigade TOCs.

1. Introduction

This paper summarizes insights developed during the 1st Brigade Task Force Lanes Exercise relative to the Custom Tent shelter used for the Combat Information Cell (CIC) of the 1st BCT Main CP. Through the TOC Summit venue, it was recognized that the currently fielded shelter system might be inadequate for future U.S. Army digitized TOCs. The commander of the Combined Arms Center (CAC) directed the TRADOC Analysis Center-Fort Leavenworth (TRAC-FLVN) to provide an analysis to inform the November 2000 committee's decision on the system to select for the U.S. Army's future division-level and brigade-level TOCs. Consequently, TRAC-FLVN requested ARL-HRED to provide a human factors evaluation of the Custom Tent Design to support TRAC-FLVN's overall analysis. This effort considered both the TOC layout and internal operations for personnel requirements, information flow, and current operations decision making. To fulfill this effort, ARL-HRED developed a survey instrument (see Appendix B) to assess human factors, battlefield management, staff collaboration, equipment modularity, mobility, and security issues.

2. Background

The U.S. Army currently fields the Modular Command Post System (MCPS), formerly known as the Standard Integrated Command Post System-Extensions (SICPS-E), with its command post vehicles (CPVs). The MCPS consists of tents and bootwalls that connect the vehicles to the tents. Command Posts (CPs) at all echelons use this system to create a common workspace which allows commanders and staffs to perform C3 functions, fuse information, and the myriad of tasks required during military operations. Although the currently fielded MCPS allows for the establishment of a common workspace, it does not provide an open architecture

within which staffs can better perform their functions. An open architecture allows for an uninterrupted view of CIC displays and unimpeded movement of personnel within the shelter. The MCPS is not adequate because of architectural support poles that break up the TOC's common workspace.

The U.S. Army doctrine specifies the types and functions of CPs at all echelons of command. The functionality offered by these various CPs has always focused on the warfighting doctrine of the Army. However, the doctrine allowed the commander to tailor the unit's CPs to meet the commander's needs and preferences as long as the doctrinal functionality was achieved. Consequently, CPs have always been as unique as the commanders operating in them. The wide variety of needs and preferences, coupled with changes in task organization and equipment, led to countless solutions for a CP's configuration. While the functionality found in CPs remained the same across units (coordinating and special staff activities), the physical organization and internal standing operating procedures (SOPs) were different based on the individual commander's requests. Organizations throughout the U.S. Army pursued TOC development programs to meet their needs. This led to redundant TOC development efforts that achieved varying results.

In early 1997, the Vice-Chief of Staff, Army (VCSA) established a policy to address TOC development. The intent of this policy was to focus all of the unique TOC development efforts that were known at that time. The goal for the U.S. Army of the future was a TOC compatible with all U.S. Army forces and interoperable with joint and combined forces. The purpose was not to impose a single standardized inflexible CP that would not meet the needs of all users. Rather, the intent was to leverage all of the financial and intellectual efforts from across many communities to focus on systems that would provide commanders and their staffs the facilities

and information required for optimizing military decision-making processes. The “clearing house” task for focusing TOC development efforts was the Training and Doctrine Command (TRADOC) Program Integration Office-Army Battle Command System (TPIO-ABCS).

In early 1999, HQ TRADOC and the Army Digitization Office (ADO) requested that a high-level group address the issues that resulted from the complexity of TOC development. The result was a forum known as the "TOC Summit." The TOC Summit held an issue review board meeting in May 1999 and its first summit meeting on 3 June 1999. The TOC Summit continues today as the forum through which TOC development is focused. Through this venue, the shortcomings of the MCPS (e.g., lack of flooring, poles in the central work area, gaps in roof sections) led to the realization that the currently fielded system was inadequate for future Army TOCs. The commander of the Combined Arms Center (CAC) directed that the TOC program manager (PM-TOC) pursue a range of alternatives with a modular architecture and allowed the lower echelons (i.e., battalions & brigades) to use soft architectures and higher echelons (division level and above) to use hardened architectures. The CAC commander also tasked the TRAC-FLVN to provide analyses to inform the November 2000 decision committee on the system to select for the U.S. Army’s future division-level and brigade-level TOCs. Consequently, the TRAC-FLVN requested the ARL-HRED to provide human factor analysis support.

3. Study Objective.

To provide Human Factors analyses regarding the Custom Tent Design as input to TRAC to inform the November 2000 decision committee on the form (platform or shelter) to select for the Army’s future division-level and brigade-level TOCs.

4. Scope.

This analysis primarily focuses on the Custom Tent shelter used for the Combat Information Cell (CIC) of a Battalion or Brigade Tactical Command Post.

5. Assumptions.

The following assumptions were developed based on requirements identified in the ABCS Critical Requirements Document (CRD) and information from the ABCS users in the field:

a. *An open architecture is required*. There are two primary reasons this study assumes that a collaborative and open architectural environment is required. First, it recognizes that "virtual" TOCs and "C2 on the move (C2 OTM)" capabilities are not mature given today's technology. Physical collocation within TOCs is required until C2 OTM technology becomes more fully developed. Second, this study recognizes that during the conduct of military operations, commanders will want to collocate staff functions if the mission, enemy, terrain, troops, time available, and civilian affairs (METT-TC) conditions allow. Clearly, the ability to perform C2 OTM through the use of "virtual" TOCs will enhance the survivability of the CPs when threatened by enemy forces. During Stability and Support Operations (SASO) and low threat conditions, the commander may want to create an open architecture (collocate) to increase the sustainability of C2 functions and allow for human, face-to-face interaction.

b. *The 1st Brigade Modified Table of Organization and Equipment (MTOE) serves as the standard*. This study uses the 1st Brigade MTOE as the equipment and personnel "footprint" that the given Custom Tent Design alternative (sheltering system) must accommodate.

c. *The electronic signature of the equipment is the same across the alternatives*. This study contends that there are no significant differences between the given TOC alternatives regarding electronic signature because the same command, control, communications, and computer (C4) equipment is resident in each case. Consequently, an analysis of electronic signature is not necessary for distinguishing between alternatives. This does not imply that an electronic signature analysis is not required to answer other relevant survivability questions outside the purview of this study.

6. Issues and Configuration Tested

a. Major Issues.

Several major issues were considered for the improvement of TOC operations. They were concerned with the TOC's tactical mobility, execution of C2, interior environment, equipment and personnel arrangements, modularity, flexibility, and security. In addition, human factors considerations for the alternative TOC interior light levels and ambient noise were made.

b. Custom Tent Design.

Numerous manufacturers can provide custom-built tents. Figure 1 depicts soft-walled, internal-framed custom tents built to user specifications by the Custom Canvas Manufacturing Company (Buffalo, NY). Because the shelter is built to user specifications, it is configurable for vehicle booting and expandable, limited only by the physical constraints of the framing system. Materials vary but are normally the same as those used in MCPS type systems. Most manufacturers include flooring, ground covers, and repair material and equipment in addition to the actual tent.

Figure 1 depicts tents that the 3ID had built in its efforts to increase the deployability and reduce the signature of its DMAIN. The Custom Canvas Mfg. Co. built these tents based on unit specifications and material samples. These tents are built to MCPS specifications but provide the open architecture that the MCPS does not. Custom tents are currently in use by the XVIII Airborne Corps (82d Abn Div and 3 ID) and other military units. The tents provide blackout capability, can be heated and cooled, are man-portable, are connectable and expandable with currently fielded MCPS systems, and can be easily transported and erected.

Figure 1. External views of Custom Tent Design.

Common among all of the alternatives are the facts that they do provide 24-hour continuous operations functionality and facilitate the use of the Common Operating Picture (COP). However, the alternatives do not provide ballistic protection from direct or indirect fire, nor do they provide over-pressurization capabilities or High-Altitude Electromagnetic Pulse (HEMP) protection.

7. Methodology.

As the lead agency responsible for analyzing human factors aspects of major issues of the Custom Tent Design, ARL provided the following resources and assessment materials: (a) three HFE Subject Matter Expert (SME) observers and (b) an HF Questionnaire (see Appendix B-1) that was administered to the entire TOC staff.

Data collection consisted of SME observations, measurements of the physical layout of personnel and equipment, the responses from the Human Factors survey for 24 staff members, interviews, and information provided by the military unit. The duty positions surveyed are listed in Table 1. This data will be used in the analysis to provide human factors evaluation information to the November 2000 decision committee.

Table 1
Command Post Duty Position Surveyed

Position
1. Advanced Field Artillery Tactical Data System (AFATDS) Operator
2. FSE (Fire Support Element)
3. Brigade Targeting Officer
4. Brigade Fire Support Officer (BDE FSO)
5. G-2 DTAC Non-Commissioned Officer-in-Charge (NCOIC)
6. Military Intelligence (MI) ACT
7. S-2 (Day Shift) All Source Analysis System (ASAS) Operator
8. 1 BCT-4ID TF XXI
9. S-2 NCOIC
10. Battle CPT
11. Operations (OPN) SGT MAJOR
12. G-3 Operations Sergeant
13. S-3
14. Radio Telephone Operator(RTO) for S3
15. Operations (OPN) SGT
16. S-3 Engineer
17. S-6 BN Level
18. S-G (299 Eng S-3)
19. G-6
20. Tactical Automation Specialist (MOS 74B)
21. Executive Officer (XO)
22. S-6
23. BDE S-2
24. Military Intelligence (MI) ACT NCOIC

8. Results of Issue Considerations

A. Tactical Mobility

The study issue here is whether or not the TOC alternative is mobile. The Essential Elements of Analysis are as follows:

(1) What are the critical C2 times/events during CP displacement operations given the TOC alternative?

(2) Does the given TOC alternative facilitate employment (set-up) and march order (tear down) of the digitized division's CPs (short moves, whole CP as march unit)?

(3) Does the given TOC alternative facilitate continuous C2 operations during displacement of the echelons (Interim C2 OTM)?

(4) Does the given TOC alternative facilitate the digitized division's ability to establish fully operational CPs?

(5) Is the given TOC alternative able to sustain movement (rate and terrain) commensurate with the combat systems of the organization's MTOE?

(6) Does the given TOC alternative meet mobility objectives and/or thresholds identified in the ABCS CRD?

(7) Does the given TOC alternative allow for quick set-up and tear-down? (ARL)

Regarding tent installation, 37% percent of the staff that completed the survey felt that the Custom Tent design highly facilitated quick set up and all felt that it was as good or better for installation than the MCPS The Custom Tent set-up time was approximately 60 minutes per tent for the 1 BCT TOC. Extreme weather (e.g., wind, cold temperatures, & rain) increased the time as did the inexperience of all personnel. The military unit personnel believed that set-up time could be reduced to 20 minutes once they were trained. Although the time required to set up and

boot four MCPS systems was not observed during this exercise, NCO's stated that the Custom Tent could be established much more quickly than four booted MCPS systems.

Regarding tent disassembly, 33% of the surveyed staff felt that the Custom Tent design highly facilitated quick tear down and all responded that it was as good or better in this respect than the MCPS. However, even though the potential for quick disassembly of the Custom Tent exists, the 1 BCT Main CP required approximately 4.5 hours to march order (i.e., disassemble and prepare the TOC equipment and Custom Tent for movement). This time appears to be long but is explainable considering the unit's current lack of training and experience. Better SOPs and more training are expected to reduce this time. Some of the extra time required to march order was consumed by the unit's using three heavy expanded mobility tactical trucks (HEMTTs) from the FSB and moving floor boards, sandbags, and miscellaneous TOC equipment. Some of this preparation time might be reduced by the shared knowledge of an SOP for loading plans and priorities of work.

The Custom Tent configuration did offer the potential for continuous C2 operations during the displacement of echelons because all the ABCS major components were housed in the C2Vs or "1068" vehicles. The staff was able to maintain continuous audio connectivity up to the time when the vehicles moved. One complaint was that the BFA operators remained inside the vehicles which inhibited task sharing and crosstalk but promoted a quicker march order.

The majority of the staff felt that the lack of portability of the Custom Tent design hindered (i.e., 5.3%) or only "borderline supported" (i.e., 20.8%) the mobility of the military unit (χ^2=8.93, $p<.25$). At present, the personnel in a designated vehicle in the TOC is responsible for breaking down, packing and transporting each MCPS. A Standard Operational Procedure (SOP) is needed to determine which vehicles will transport the various parts (e.g., roof, sides, poles,

floor) of the Custom Tent design. The shared knowledge of such procedures will help to quicken the mobility of the military unit.

Several needed improvements were reported or noted during setup or breakdown. First, the Custom Tent poles need to be labeled and colored-coded to assure easier matching of horizontal with vertical poles. Secondly, the pins holding together the Custom Tent platform were easy to remove when compared to the nuts and bolts of the MCPS. The use of the pins facilitated quicker set up and disassembly. However , the pins need to be ruggedized because during a Custom Tent disassembly it was observed that several of the pins broke which delayed the frame poles from being taken apart. On another occasion, during setup, several of the pins were bent which delayed the erection of the Custom Tent frame. Thirdly, another improvement involves a system to facilitate the handing of cables and wires within the Custom Tent. This system may possibly consist of clips attached to the tent frame that will be readily available to hold and group the cables and wires in an organized manner.

B. 1st Brigade CIC Layout.

This study issue was whether or not this Custom Tent alternative allowed the digitized division to effectively exercise C2. Therefore, this section quantifies the ability of the Custom Tent used in the 1st Brigade CIC layout to provide adequate space for CP equipment and personnel and its ability to facilitate C2 operations. The EEAs are:

(1) Does the given TOC alternative facilitate C2, battle tracking, and info sharing?

(2) Does the given TOC alternative support user-friendly man-machine interfaces and standardized equipment requirements?

(3) Does the given TOC alternative meet functionality objectives and/or thresholds identified in the ABCS CRD?

(4) Does the given TOC alternative provide adequate space for CP equipment and personnel, and does it facilitate TOC operations?

(5) Does the given TOC alternative facilitate the commander's ability to exercise C2?

The 1st Brigade layout provided more than adequate space for CP equipment and personnel during military operations. Figure 2 shows the overall layout of the 1st Brigade TOC including the CIC area. Figure 3 shows a more detailed view of the CIC section. Based on the HF survey, 96% of the staff members (χ = 21.6, p<.01) felt that the physical dimensions of the Custom Tent provided adequate space for digitized and non-digitized equipment. Also, 83% of the staff members (χ=10.7, $p<.01$) stated that the physical dimensions of this design provided adequate space for the number of personnel required for effective TOC operations. Most of the time there appeared to be unneeded room in the MCPS shelters attached to the 1st BCT Main CP Custom Tents. These spaces were needed only when TOC briefings were conducted. Possibly, the TOC with its attached vehicles could be reconfigured to eliminate the need for, at least, one of the two MCPSs used in this study.

Personnel could easily change their locations to correspond to specific METT-TC operations at the discretion of the commander or battle captain. No BFA had to be dedicated to a specific table computer. Each BFA's laptop computer could be picked up and plugged into the local area network. Most of the wires were located at a 7-foot height where the walls joined the ceiling sections. The tables were not anchored which allowed for layout flexibility. In addition, the height of the command tables was approximately 28 inches which corresponds to conventional HF ergonomic guidelines. Most of the staff (63%, χ^2=2.25, *N.S.*) felt that the Custom Tent design supported easy integration of ABCS and associated communication

networks and nodes. The staffs' opinion on a quick establishment of an integrated communication system was mixed. Only 37.5% of those surveyed rated the TOC system as facilitating a quick establishment. The lack of an established and standardized TOC wiring diagram was felt strongly. This brigade's 74B was working toward creating such a diagram.

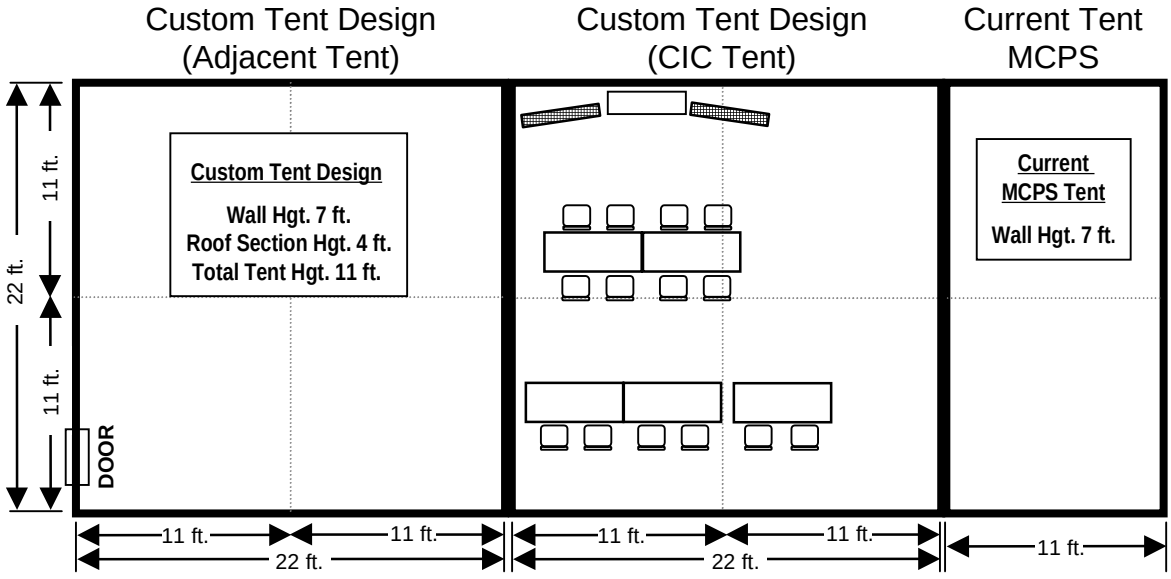

Figure 2. Layout of the DTAC during the 1st brigade task force exercise at Fort Hood, Texas using the two custom tent designs and the current MCPS tent (March 2000).

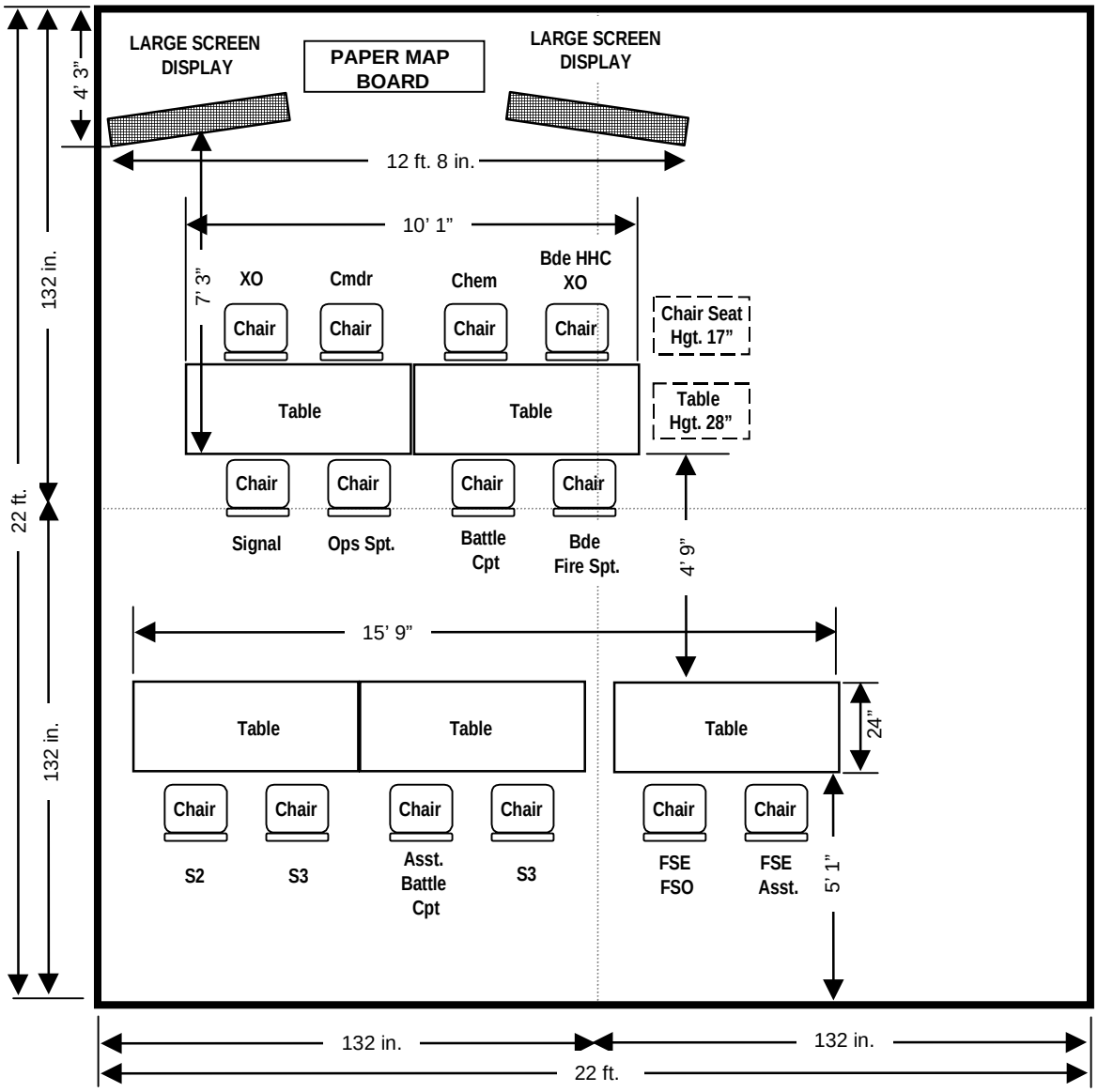

Figure 3. Layout of the combat information cell (CIC) using the custom tent design during the 1st brigade task force exercise at Fort Hood, Texas (March 2000).

The 1st Brigade Custom Tent with its open architecture configuration was regarded as facilitating the commander's ability to exercise C2 in the CIC to some degree. The commander had the ability to rearrange functional elements to meet METT-TC requirements. The commander had access to each member of the staff throughout the exercise and his command presence was in clear view of the entire staff. All the staff teams could easily see and hear the

commander. The staff rated the commander's ability as "high" to (1) observe the staff (66.7%, χ^2 =15.57, p<.01), (2) implement risk management (58.3%, χ^2 =18.07, p<.01), (3) easily provide the staff with guidance and monitor activity (70.9%, χ^2=20.15, p<.01), (4) focus the activity of the staff as desired (54.2%, χ^2=7.24, p<.86), and (5) position himself in order to maintain an active command presence (79.2%, χ^2 =20.99, p<.01).

The 1st Brigade Custom Tent promoted efficient internal staff communications and total staff integration. The battle major, battle captain, G3, and operations officer (maneuver team) worked effectively as a team in providing the commander the maneuver information and screen displays he required to support his decision making. The staff surveyed felt that the modified tent design promoted BOS integration during the planning (54.2%,χ^2 =17.5, p<.01), preparation (58.3%, χ^2 =24.3, p<.01) and execution phase (58.3%,χ^2 =20.99, p<.01) of decision making. There was adequate room to promote team huddles which supported collaborative planning (79.1%,χ^2 =27.7, p<.01) and synchronization (83%, χ^2 =14.32, p<.01). The majority of the staff felt that the TOC design supported (20.8%) or promoted (58.3%) task sharing and teamwork within and among the staff leader teams (χ^2 =11.83, p<.03). Similarly, the open architecture promoted workload distribution among the staff (70.8, χ^2 =14.32, p<.01).

The personnel line of sight view of the situational map varied. This staff team working at the first row of tables in the CIC had a clear view of the FBCB2 situational map as well as the wall-mounted paper map with friendly and enemy updates and UAV information directly in front of them. The battle captain was able to supervise the efforts of the staff NCOs, conduct analyses and assessments of available information, assist in the review and dissemination of information from the other BFAs, and assist in monitoring the location and activity of friendly units. The battle major monitored and updated the information displayed on the electronic display screens

and paper maps. However, the staff in the back row of tables of the CIC had some problems viewing the map boards and large screen displays. One suggestion was that the rear tables (see Figure 3) should have one or two computer monitors to view the Common Operational Picture (COP).

C. Interior Environment.

This study issue was whether or not the TOC alternative provided CPs that were interchangeable, expandable, and adaptable to meet changing mission needs. The EEAs are:

(1) Does the given TOC alternative CIC cool to 85^{o} F and heat to 50^{o} F and offer limited climate control elsewhere in the TOC?

(2) Is the given TOC alternative climate control consistent with currently fielded systems?

(3) Does the given TOC alternative prevent water/snow/wind from entering the TOC interior and interfering with CP operations in inclement weather?

(4) Is the given TOC alternative able to be integrated into/supported by the Army logistical support system and does it introduce any unique logistical support requirements?

(5) Does the given TOC alternative prevent typical battlefield conditions from adversely affecting CP operations (smoke, dust)?

The Custom Tent was relatively watertight when compared to the MCPS. The larger size of the Custom Tent reduced the need for gutters at the connecting points which often leaked. Consequently, though it rained intensely for many hours, no significant water was observed to leak from the ceiling attachments involving the Custom Tent Designs. However, it was noted that some connector pin assembly parts had broken which were used to connect the roof sections of the tents. Therefore, it is recommended that the connector parts be ruggedized to withstand the battlefield environment. If possible, the connector parts should remain attached to

appropriate tent sections, even when the tent sections themselves are not connected, so that the connector parts will be available when needed and not get misplaced during frequent TOC relocations.

Another problem associated with the interior TOC environment and rain is the mud that can result on the ground space under the tent area (see Figure 4a). Though the Custom Tent design included a tarpaulin floor it did not prevent water getting into the TOC ground space and causing severe mud development on the floor. The mud was sticky and built up on the shoes of the TOC personnel which slowed their military performance. At one TOC location (i.e., TOC "A"), raised wooden floor sections, provided by local test support personnel, were successful in preventing mud problems. However, at another TOC location (i.e., TOC "B"), a large one-piece tarpaulin ground-level floor was provided that was not successful in preventing mud buildup. An additional problem occurred when the TOC B was disassembled and the military personnel tried to fold and place the single-piece floor material onto a truck (see Figure 4d). The mud on the tarpaulin caused the material to be so heavy and unmanageable that the personnel were initially unable to move it. After repeated futile attempts with many personnel and failed problem-solving ideas, the tarpaulin was loaded with difficulty onto the back of a truck (see Figure 4f). It was suggested that the tarpaulin floor be made in sections for easier handling. However, the fact that the ground-level tarpaulin did not prevent severe mud buildup suggests that a tarpaulin floor is not a good solution.

a. b. c.

d. e. f

Figure 4. Disassembly and loading of the Custom Tent for movement to another site.

Other environmental issues involved temperature, ventilation, and noise within the Custom Tent shelter. The environment was rated adequate or high (80%) for temperature (χ^2 =17.37, p<.01), (70.6%) for ventilation (χ^2 =10.27, p<.05), and (89.2%) for noise (χ^2 =21.54, p<.01).

Regarding safety, one potential TOC safety hazard that was noted involved personnel climbing on the Custom Tent to disassemble the camouflage netting. It was cumbersome and, perhaps, unsafe to climb on top of a tent that is 11 feet high and not intended to support the weight and movement of soldiers.

D. Modularity.

This study issue was whether or not the TOC alternative is extensible to future concepts and provides modularity to meet the needs of commanders and considerations of METT-TC. The EEAs are:

(1) Is the given TOC alternative extensible to future operational concepts identified in TRADOC Pam (TP) 525-66, ATDs, ACTD, and other future concept efforts?

(2) Can the given TOC alternative physically and adequately integrate joint, multi-national, and coalition forces?

(3) Does the given TOC provide CPs that are interchangeable, compatible, expandable, and adaptable to meet changing missions and needs?

(4) Does the given TOC alternative meet adaptability objectives and/or thresholds identified in the ABCS CRD?

The Custom Tent meets the above criteria. It can be transported by aircraft, ships, trains, and trucks and moved by material handling equipment.

The soldiers were asked to rate the modularity of the system design to allow for open TOC architecture to support the Commander's layout preferences for the arrangement of equipment and personnel. In other words, could the TOC be constructed with the standardized units and dimensions but have enough flexibility in construction to support the Commander's layout preference? When asked to rate the adaptability of the TOC design to accommodate large screen displays and multiple displays, 83.4% of the soldiers stated that it was adaptable. Only 12.5% rated the modularity of the system design as hindering the ability to construct an open architecture design (χ^2=20.29, p <.01).

The majority of the staff surveyed highly rated the ability of the modified tent design to accommodate large screen displays (70.9%, χ^2 =11.0, p<.05), and multiple displays in horizontal or vertical configurations (68.8%, χ^2 =30.84, p<.01).

E. Flexibility.

This study issue is related to the flexibility and open architecture of the TOC design to affect the performance of tasks related to mission, enemy, terrain, troops, and time available (METT-TC). Open architecture is essential because during military operations commanders will want to collocate staff functions to enhance the performance of tasks related to METT-TC. This will increase the sustainability of C2 functions and allow for face-to-face interactions. As a result of the wide variety of commander needs and preferences as well as changes in task organization and equipment, the physical organization and the internal standing operating procedures of the TOCs change based on commander preferences. Therefore, the TOC must be flexible in order to meet the needs of all users, including all Army forces ad interoperable with Joint and Combined Forces. In other words, the TOC must have the ability to be tailored to meet the commander's needs and preferences while maintaining the functionality required by doctrine.

Ninety-six percent of the soldiers (χ^2 =20.15, p<.01) rated the flexibility and open architecture of this design as supporting the performance of tasks. They stated that ATCCS with the large screen displays allowed real time action for the commander and that the Jupiter gave the commander a versatile tool to manipulate and display this data. It was also stated that this design provided excellent ability to switch feeds from the various boxes through the DPV to display information on a large screen. The only negative comments were due to either power failure and equipment failure.

F. Security.

Although a detailed technical analysis of electronic signature was beyond the scope of this study, questions about security were asked. The EEAs are:

(1) Does the given TOC alternative enhance the ability to employ concealment techniques and camouflage?

(2) Does the given TOC alternative allow the employment of noise, light, thermal, and physical evidence control?

(3) Does the given TOC alternative facilitate protection from surprise, observation, detection, interference, espionage, terrorism, and sabotage?

Only 45.8% of the soldiers rated the TOC system design able to support concealment and camouflage techniques (χ^2 =4.04, p=N.S.). As confirmation, only 4.2% stated that it greatly facilitated. No light could be seen escaping from the TOCs at night. Fifty percent (χ^2 =12.4, p<.03) of the staff surveyed felt that it would be hard to take measures to prevent observation and detection. This was the first time that the Custom Tent configuration was camouflaged. The respondents stated that the size of the TOC layout and the noise level from the numerous vehicles and generators would cause the TOC to be an easy target. This problem exists regardless of the TOC configuration used.

When asked how the did this TOC design affect the ability to control thermal signature, only 25% (χ^2 =14.74, p<*.01*) felt that it could be controlled. The numerous vehicles and generators added to the thermal signature problem.

Only 41.7%% (χ^2 =7.49, p=N.S.) of the soldiers indicated that this TOC design aided the ability to control physical TOC evidence (signature). None of the respondents stated that this

design greatly facilitated their ability to control the signature. Once again, the size of the TOC layout and the noise level from vehicles and generators made the TOC an easy target.

When asked how well did the TOC system design allow the staff to take measures to protect from surprise, observation, and detection, 45.8% (χ^2 =12.37, $p<.025$) stated that it either borderline supported or facilitated measures of protection. However, no one stated that it greatly facilitated. It was stated that with thermals, the TOC could be seen and heard. This is due to its size (i.e., numerous connected military vehicles and generators). There was concerned expressed that the signature is too large to be within FM (radio) range of forward BCTs.

Sixty-six percent of the soldiers (χ^2 =12.9, $p<.025$) stated that the TOC design would allow the staff to take measures to protect from espionage, terrorism or sabotage. However, only 8.3% of the respondents stated that it greatly facilitated their ability. The TOC did not provide ballistic protection from direct or indirect fire. In addition, the TOC does not provide over-pressurization capabilities or high-altitude electromagnetic pulse (HEMP) protection. Also, it was stated that there were no weapons except personal weapons for protection.

G. Interior Light Levels.

It was desired to know what the general illumination levels were at representative locations within the 1st brigade TOCs. The light levels were measured by using a Gossen Luna-Pro light meter placed with the sensor in an upward position to record the ambient incident light at representative work locations indicated in the Figures 5 and 6. Table 2 shows the scale number indicated by the light meter and the equivalent readings in foot-candles and Lux (see Appendix E).

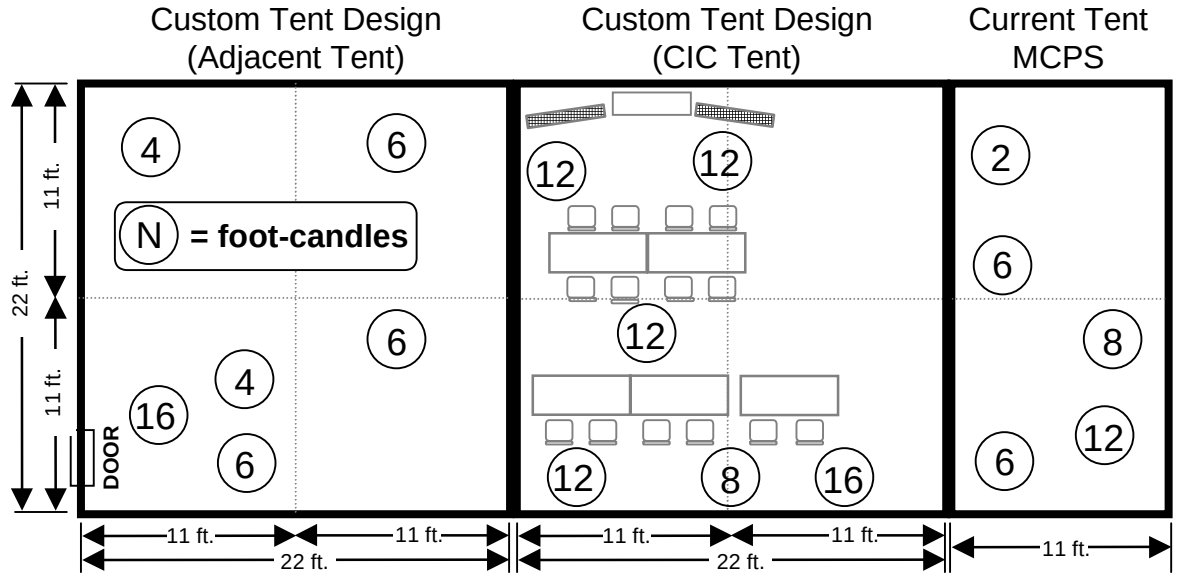

Figure 5. Diagram showing the sources of illumination at TOC A.

The sources of illumination in the 1st brigade TOC "A" (see Figure 5) were fluorescent work lights located at a height of approximately 7 feet. The TOC CIC operations using the Custom Tent design were conducted in incident light levels ranging from 8-16 foot-candles. These levels of illumination are adequate for normal detail but not for prolonged periods of reading printed material (see Appendix F). The levels of illumination in the adjacent Custom Tent design, which

support the CIC, ranged from 4-16 foot-candles. At the opposite side of the TOC was a current tent design, the MCPS, which had light levels ranging from 2-12 foot-candles. The TOC areas which supported the CIC had lower light levels than the CIC but the requirement for prolonged periods of reading printed material was also less.

Based on the HF survey, 71% of the military respondents felt that the brightness of the light in the TOC was "adequate" and an additional 21% felt that the brightness was "excellent" (χ^2 =41.65, $p<.01$). When asked how the ambient lighting affected C4IS operations, 71% of the respondents felt that these operations were "somewhat facilitated" and an additional 12% felt they were "greatly facilitated" (χ^2 =41.97, $p<.01$). Regarding how the TOC design affected the ability to control lighting, 67% of the respondents indicated that lighting control was "somewhat facilitated" and an additional 8% felt that this lighting control was "greatly facilitated." However, 17% felt that lighting control was "somewhat" or "seriously hindered."

The respondents made suggestions to improve the usefulness of the CP: (1) provide support in tents for lights, (2) provide readily available hangers to mount the lights, and (3) provide improved light sets.

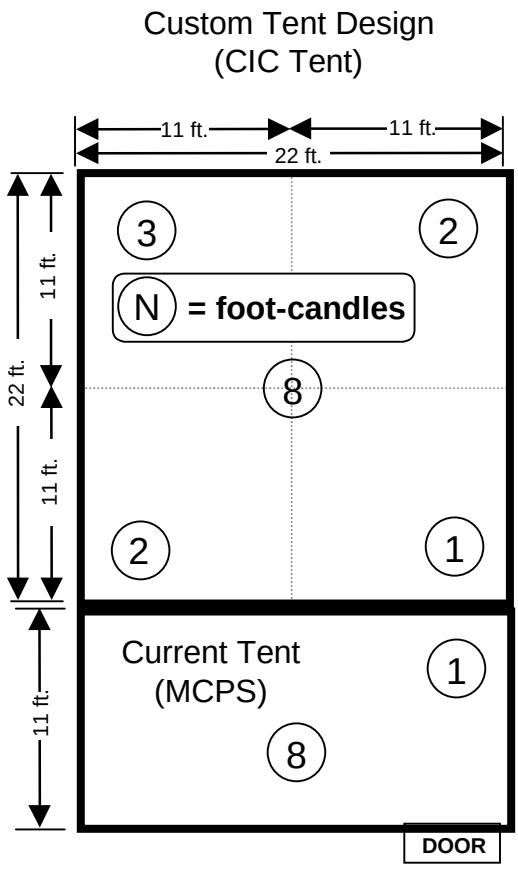

Figure 6. Diagram showing the sources of illumination at TOC B.

A TOC at another location (i.e., TOC "B") had its fluorescent work lights mounted in the upper 4-foot section of the Custom Tent design ceiling (see Figure 6). Thus, the source of illumination for the TOC B was several feet higher than existed for the TOC A. The resulting work level lighting for the higher mounted lights ranged from 1-8 foot-candles in the Custom Tent. The light levels in the adjacent MCPS tent also ranged from 1-8 foot-candles. Overall, the lighting levels in work areas for TOC B were lower than for TOC A. The lighting level at any given location appeared to be most directly related to the distance from the light source. Consequently, the overall light levels in TOC B, with the higher mounted light sources, resulted in lower light levels in the work areas than for TOC A.

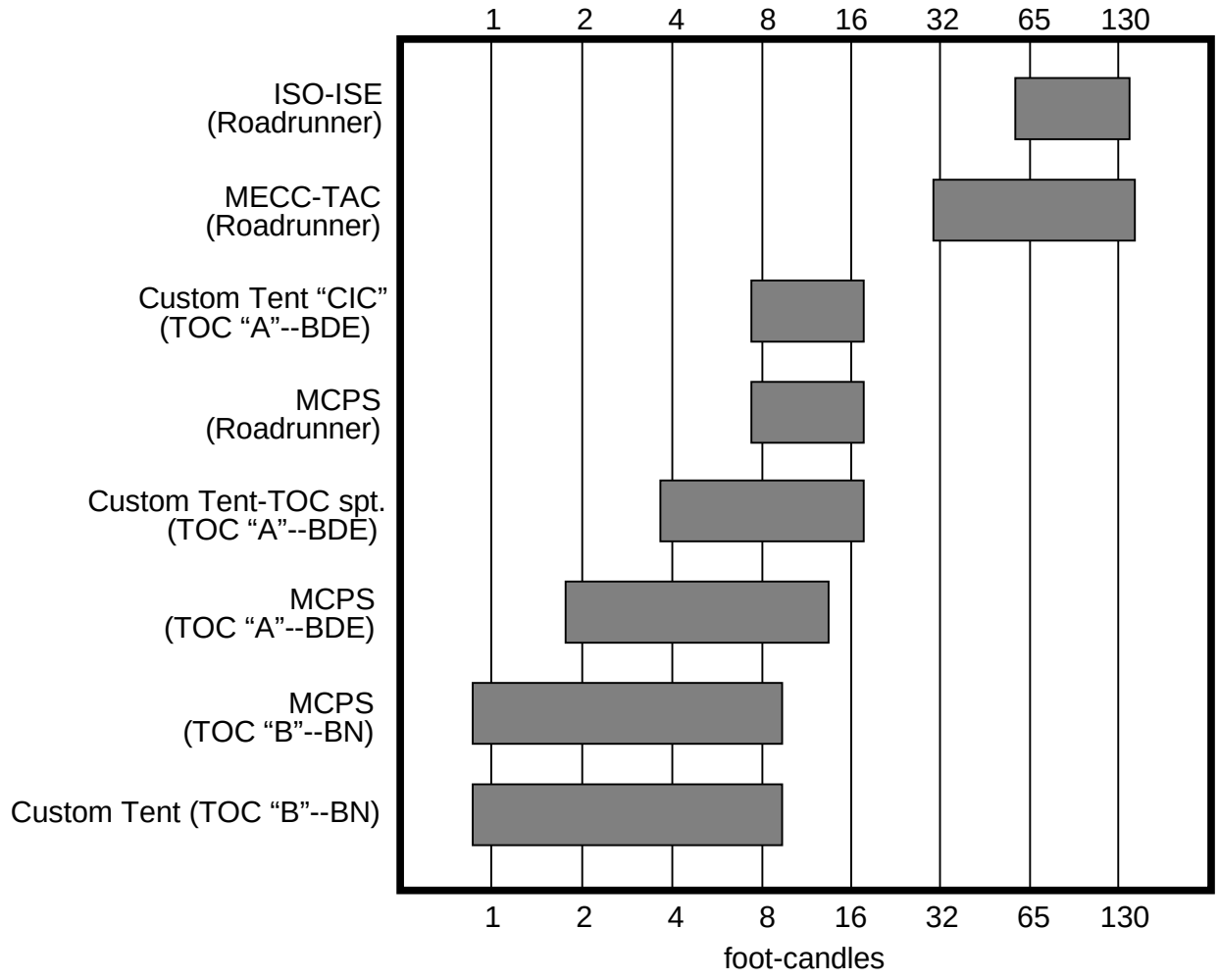

Figure 7. A comparison of light levels for various concepts of tactical operations centers(TOCs).

A comparison was made for the light levels of the TOCs observed in this study and a previous study (i.e., the 4th Infantry Division's III Corps Roadrunner and Iron Horse Sprint exercises). The light level ranges are presented in Figure 7. Overall, it can be seen that the light levels (i.e., 32-130 foot-candles) were higher when using the Mobile Expandable Container Configuration

(MECC) shelters for the CIC and the Information Support Element (ISE). However, a lower amount of ambient light (i.e., 10-20 foot-candles) may be more desirable for TOC operations that consist of viewing ABCS computer and large screen displays (see guidelines in Appendix F).

.

Table 2

Incident Light Levels

Scale No.	Foot-Candles	Lux
5	0.26	2.8
6	0.50	5.5
7	1.00	11.0
8	2.00	22.0
9	4.00	44.0
10	8.00	88.0
11	16.00	175.0
12	32.00	350.0
13	65.00	700.0
14	130.00	1400.0

H. Sound and Noise Levels.

It was desired to know what the general sound or noise levels were at representative locations within the Brigade TOC using the custom tent design.. The sound levels were measured using a sound level meter placed with the sensor in a horizontal position to record the sound level at specific work locations indicated in the Figures 5-6. The accuracy of the meter at 144 dB was ±2 dB. When set on the "A" weighting, the meter measures frequencies in the 500-10,000 Hz range which is the area of greatest sensitivity to the human ear. When set to the "C" weighting, the meter measures uniformly over the frequency range from 32-10,000 Hz, giving an indication of the sound level at a wider range.

The current 1st brigade TOC operations were conducted in average noise levels ranging from 67-78dB using the A weight and 79-83 dB using the C weight. This level of background noise was loud but did not exceed the steady state noise hazard requirement of 85 dB measured (using the A weight) as specified in Army Pam 40-501. The source of the loud background noise was due to the turbine engines of the C2V along with the primary power unit (PPU). The majority of the staff felt that they could not control the noise levels (67%, $\chi 2 = 17.66$, $p < .01$). The sound readings at the engine exhaust box were measured resulting in an average of 89 dB with the A weight and 92 dB with the C weight. Sound protection around these vehicles is required. The noise levels at various positions can be found in Table 3.

Table 3

Noise levels (dB) obtained within the digitized Brigade TOC using a Custom Tent Design

Position	Weighting	Average (dB)	Peak (dB)
S2	A	71	75
	C	79	81
Battle Captain	A	74	78
	C	80	82
FSE	A	67	68
	C	82	83
S3	A	69	73
	C	80	82
Commander	A	69	72
	C	83	84

The majority (62.5%) of the staff surveyed ($\chi 2 = 10.57$, $p < .05$) felt that voice commands were easily heard throughout the TOC. Twenty-five percent of the staff surveyed felt that the design hindered the ability to control noise ($\chi 2 = 17.66$, $p < .01$). However, the majority of the

staff felt that the design promoted or at least supported efficient internal communication. (75%, $\chi 2$ =21.4%, p<.01).

I. Manpower, Personnel, and Training.

The consensus of the staff was that if the day and night shifts of the brigade or battalion staff were combined, then there was adequate manpower to set up or disassemble the CP that utilized the Custom Tent configuration. However, the majority of the staff (62.5%) surveyed expressed concern that there was not enough people to man the planning requirements of the TAC or complete all tasks that have increased because of digitization (χ^2 =2.08, p= .62). Consequently, TOC security was minimal.

Training and experience on the ABCS needs to be increased. Most of the staff was relatively new with only 2-3 months of experience. The TOC did have a couple of experienced ABCS staff members that could reconfigure and reactivate the ABCS workstations. However, the ABCS operators had to complete other TOC duties and could not devote their full attention to ABCS.

The majority of the staff surveyed (83.3%) felt that no additional personal skill identifier (ASI) or MOS was felt to be required for set up or disassembly of the Custom Tent configuration (χ^2 =10.7, p<.01). Guidance for battlefield functional area layout was received from the commanders in both the battalion and brigade TOCs.

APPENDIX A

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APPENDIX B

Tactical Operations Center
HUMAN FACTORS QUESTIONNAIRE

ARMY RESEARCH LABORATORY
HUMAN RESEARCH AND ENGINEERING DIRECTORATE

Privacy Act Statement

Authority: 5 USC § 301, Authority for the Secretary of the Army to Issue Army Regulations; AR 73-1, Test and Evaluation Policy. **Principal Purpose:** The data to be collected with this form are to be used for research and evaluation purposes only. **Routine Uses:** This is an experimental data collection questionnaire developed by the Test and Experimentation Command pursuant to its research and testing mission as prescribed in AR 73-1. When identifier (name and social security number) is requested they are to be used for administrative and statistical control purposes only. Full confidentiality of the responses will be maintained in the processing of these data. **Disclosure:** Completion of this questionnaire is required for this test. You are encouraged to provide complete and accurate information in the interests of research and testing, but there will be no effect on individuals for not providing all or part of the information.

Instructions

The purpose of this questionnaire is to record HUMAN FACTORS data on CIC Command Post (CP) designs. Your answers will not be given to or shown to anyone except those who are assessing CIC for the Army. (For example, none of your information will be given to your chain of command or put in your personnel file.) Your answers will be treated confidentially. Please fill out the questionnaire carefully. If you need additional space to answer a question, indicate by an arrow (→) and continue on the back of the page. Be sure to number the item on the back of the page. If you have any questions concerning this questionnaire, please contact an ARL or TRAC team representative for help.

Thank you for your help

1) Name: Last _____
First _____
Middle Initial _____

2) User PIN: _____
(First initial of last name and last four digits of social security number)

3) TOC Configuration: a. STCPS ____ b. DRASH ____
c. CUSTOM TENT ____ d. MECC ____ e. Large SICPS ____

4) Command Post Duty Position:
_____(e.g., G-2, G-3, Operations Sgt, Commander)

5) Shift: a) Day: _____ b) Night:_____

I. MANPOWER/PERSONNEL

1) Were there an adequate number of personnel available in your Command Post (CP) to perform operations including setup and breakdown?

☐ Yes ☐ Do Not Know ☐ No ☞ Please explain: _____

_____

_____

_____

2) Did you require personnel augmentation in order to perform CP operations including setup, breakdown, camouflage and security?

☐ No ☐ Do Not Know ☐ Yes ☞ To perform which functions ☐ (Day) ☐ (Night)?

_____

_____

_____

3) Were there enough ABCS personnel (manpower) in your CP to reconfigure and reactivate workstations? ☐ Yes ☐ Do Not Know ☐ No ☞ Please explain:

_____

_____

_____

4) Were there enough personnel in your CP to prevent mission delays?

☐ Yes ☐ Do Not Know ☐ No ☞ Please explain:

_____

_____

_____

5) Do the personnel skills required to setup/breakdown the TOC necessitate a specific Additional Skill Identifier (ASI) or unique MOS?

☐ Yes ☐ Don't know ☐ No ☞ please explain:

_____

_____

_____

II. TRAINING

1) Did you receive formal training on this TOC configuration regarding setup and breakdown.

☐ No ☐ Yes ☞ When: _____month _____year

2) Did you receive formal training on internal TOC layout ?

☐ No ☐ Yes ☞ When: _____month _____year

3) Did you receive instruction from your commander regarding interior layout for your specific Battlefield Functional Area?

☐ Yes ☐ No ☞ please explain:

_____ _____
_____
_____

III. HUMAN FACTORS

1) The noise level of your work area while operating within the CP was:
   ☐ Very Low ☐ Low ☐ Borderline ☐ High ☐ Very High
2) The intensity (brightness/darkness) of light in the TOC was:
   ☐ Excellent ☐ Adequate ☐ Borderline ☐ Inadequate ☐ Very Poor
3) The view of the situational map from your work area was :
   ☐ Excellent ☐ Adequate ☐ Borderline ☐ Inadequate ☐ Very Poor
4) Does the system design facilitate quick setup?

   ☐ Yes ☐ No ☞ please explain: _____
_____
_____

5) Does the system design facilitate quick breakdown?
   ☐ Yes ☐ No ☞ please explain: _____
_____

6) Rating of how the portability of the components of the TOC design system affects the mobility of the military unit:

(1) Seriously Hindered	(2) Somewhat Hindered	(3) Borderline Support	(4) Somewhat Facilitated	(5) Greatly Facilitated

7) Did the physical dimensions of the system design provide adequate space for digital and non-digital equipment:

   ☐ Yes ☐ No ☞ please explain: _____
_____
_____

8) Did the physical dimensions of this TOC design provide adequate space for the number of personnel required for effective TOC operations:

☐ Yes ☐ No ☞ please explain: _____
_____
_____

9) Rating of this TOC design to allow for optimal arrangements of equipment and personnel that facilitated the ease of access to information displays:

(1) Seriously Hindered	(2) Somewhat Hindered	(3) Borderline Support	(4) Somewhat Facilitated	(5) Greatly Facilitated

10) Rating of the how the physical dimensions of this TOC design affected the efficiency of communications among personnel:

(1) Seriously Hindered | (2) Somewhat Hindered | (3) Borderline Support | (4) Somewhat Facilitated | (5) Greatly Facilitated

11) Indicate how each of the following physical conditions affected C4IS operations: (mark one ☒ per row)

	Seriously Hindered	Hindered	Supported (Adequate)	Facilitated	Greatly Facilitated
a. Ambient lighting					
b. Temperature					
c. Noise					
d. Ventilation					

12) Rating of the modularity of the system design to allow for open TOC architecture to support the Commander's layout preferences:

(1) Seriously Hindered | (2) Somewhat Hindered | (3) Borderline Support | (4) Somewhat Facilitated | (5) Greatly Facilitated

13) Rating of the adaptability of the TOC system design to accommodate large screen displays and multiple displays:

(1) Seriously Hindered | (2) Somewhat Hindered | (3) Borderline Support | (4) Somewhat Facilitated | (5) Greatly Facilitated

14) Rating of the adaptability of the TOC system design to accommodate horizontal and vertical map boards:

(1) Seriously Hindered | (2) Somewhat Hindered | (3) Borderline Support | (4) Somewhat Facilitated | (5) Greatly Facilitated

15) Rating of the flexibility and open architecture of the TOC design to affect the performance of tasks related to mission, enemy, terrain, troops, and time available (METT-TC):

(1) Seriously Hindered | (2) Somewhat Hindered | (3) Borderline Support | (4) Somewhat Facilitated | (5) Greatly Facilitated

16) Indicate how this TOC design impacted on effective C4IS operations related to METT-TC: (mark one ☒ per row)

	Seriously Hindered	Hindered	Borderline	Facilitated	Greatly Facilitated
a. Mission					
b. Enemy					

c. Troops					
d. Terrain					
e. Time Available					

17) Rating of the physical characteristics of equipment and personnel arrangements in the TOC system to contribute to a safe working environment:

(1) Seriously Hindered (2) Somewhat Hindered (3) Borderline Support (4) Somewhat Facilitated (5) Greatly Facilitated

18) Rating of the TOC system design to employ concealment and camouflage techniques:

(1) Seriously Hindered (2) Somewhat Hindered (3) Borderline Support (4) Somewhat Facilitated (5) Greatly Facilitated

19) Indicate how this TOC design affected the ability to control :
(mark one ☒ per row)

	Seriously Hindered	Hindered	Borderline	Facilitated	Greatly Facilitated
a. Noise					
b. Lighting					
c. Thermal					
d. Physical TOC Evidence (Signature)					
e. Time Available					

20) Rating of the TOC system design to allow the staff to take measures to protect from surprise, observation, detection:

(1) Seriously Hindered (2) Somewhat Hindered (3) Borderline Support (4) Somewhat Facilitated (5) Greatly Facilitated

☞ please explain: _____
_____
_____
_____

21) Rating of the TOC system design to allow the staff to take measures to protect from espionage, terrorism or sabotage:

(1) Seriously Hindered (2) Somewhat Hindered (3) Borderline Support (4) Somewhat Facilitated (5) Greatly Facilitated

22) Rating of the TOC system design to allow the Commander to provide directions and management for the TOC staff:

(1) Seriously Hindered (2) Somewhat Hindered (3) Borderline Support (4) Somewhat Facilitated (5) Greatly Facilitated

23) Rating of the TOC system design to allow the Commander to obtain information on the mission, enemy forces, friendly forces, terrain, weather:

(1) Seriously Hindered (2) Somewhat Hindered (3) Borderline Support (4) Somewhat Facilitated (5) Greatly Facilitated

☞ please explain: _____
_____
_____

24) Rating of the TOC design to allow C4I accessibility from all TOC locations:

(1) Seriously Hindered (2) Somewhat Hindered (3) Borderline Support (4) Somewhat Facilitated (5) Greatly Facilitated

25) Rating of the TOC system design to ensure that voice commands are easily heard throughout the TOC:

(1) Seriously Hindered	(2) Somewhat Hindered	(3) Borderline Support	(4) Somewhat Facilitated	(5) Greatly Facilitated

26) Rating of the TOC system design to ensure easy integration of ABCS and associated communication networks and nodes (e.g., LANs, WAN's, satellites, data facsimiles, etc.):

(1) Seriously Hindered	(2) Somewhat Hindered	(3) Borderline Support	(4) Somewhat Facilitated	(5) Greatly Facilitated

27) Rating of the TOC system design to ensure the easy visual scanning of map boards at all locations:

(1) Seriously Hindered	(2) Somewhat Hindered	(3) Borderline Support	(4) Somewhat Facilitated	(5) Greatly Facilitated

28) Rating of the TOC system design to ensure the easy and quick establishment of an integrated communication system:

(1) Seriously Hindered	(2) Somewhat Hindered	(3) Borderline Support	(4) Somewhat Facilitated	(5) Greatly Facilitated

29) Rating of the TOC design to enhance the Commander's ability to observe the staff:

(1) Seriously Hindered	(2) Somewhat Hindered	(3) Borderline Support	(4) Somewhat Facilitated	(5) Greatly Facilitated

30) Rating of the TOC design to ensure that the Commander can observe the entire staff and implement risk management:

(1) Seriously Hindered	(2) Somewhat Hindered	(3) Borderline Support	(4) Somewhat Facilitated	(5) Greatly Facilitated

31) Rating of the TOC design to create an environment for the Commander to provide the staff with guidance and monitor activities:

(1) Seriously Hindered	(2) Somewhat Hindered	(3) Borderline Support	(4) Somewhat Facilitated	(5) Greatly Facilitated

32) Rating of the TOC design to allow the Commander to focus the activities of his staff:

(1) Seriously Hindered	(2) Somewhat Hindered	(3) Borderline Support	(4) Somewhat Facilitated	(5) Greatly Facilitated

33) Rating of the TOC design to allow the Commander to always position himself in order to maintain an active command presence among the entire staff:

(1) Seriously Hindered | (2) Somewhat Hindered | (3) Borderline Support | (4) Somewhat Facilitated | (5) Greatly Facilitated

34) Rating of the TOC design to promote task sharing and teamwork among the battlestaff:

(1) Seriously Hindered | (2) Somewhat Hindered | (3) Borderline Support | (4) Somewhat Facilitated | (5) Greatly Facilitated

☞ please explain: _____
_____
_____
_____

35) Rating of the TOC design to promote workload distribution among the battlestaff:

(1) Seriously Hindered | (2) Somewhat Hindered | (3) Borderline Support | (4) Somewhat Facilitated | (5) Greatly Facilitated

36) Rating of the TOC design to promote prioritizing actions:

(1) Seriously Hindered | (2) Somewhat Hindered | (3) Borderline Support | (4) Somewhat Facilitated | (5) Greatly Facilitated

37) Rating of the TOC design configuration to permit teamwork and reduced workload:

(1) Seriously Hindered | (2) Somewhat Hindered | (3) Borderline Support | (4) Somewhat Facilitated | (5) Greatly Facilitated

38) Rating of the TOC to promote staff workload sharing and collaboration:

(1) Seriously Hindered | (2) Somewhat Hindered | (3) Borderline Support | (4) Somewhat Facilitated | (5) Greatly Facilitated

39) Rating of the TOC design to allow BFA's adequate space to advise and assist the Commander:

(1) Seriously Hindered | (2) Somewhat Hindered | (3) Borderline Support | (4) Somewhat Facilitated | (5) Greatly Facilitated

40) Rating of the TOC system design to promote collaborative planning:

(1) Seriously Hindered | (2) Somewhat Hindered | (3) Borderline Support | (4) Somewhat Facilitated | (5) Greatly Facilitated

41) Rating of the TOC design to promote synchronization:

(1) Seriously Hindered | (2) Somewhat Hindered | (3) Borderline Support | (4) Somewhat Facilitated | (5) Greatly Facilitated

42) Rating of the TOC design to permit easy visual and auditory communication to integrate TOC personnel for planning and execution:

(1) Seriously Hindered (2) Somewhat Hindered (3) Borderline Support (4) Somewhat Facilitated (5) Greatly Facilitated

43) Rating of the TOC design to provide adequate space for the assembly of staff members during wargaming:

(1) Seriously Hindered (2) Somewhat Hindered (3) Borderline Support (4) Somewhat Facilitated (5) Greatly Facilitated

44) Rating of the TOC design to provide adequate space for supervision of staff during wargaming?

(1) Seriously Hindered (2) Somewhat Hindered (3) Borderline Support (4) Somewhat Facilitated (5) Greatly Facilitated

45) Rating of the TOC design to promote the development of an accurate common operating picture (COP):

(1) Seriously Hindered (2) Somewhat Hindered (3) Borderline Support (4) Somewhat Facilitated (5) Greatly Facilitated

46) Rating of the TOC design to provide the staff an unobstructed field of view of situational maps:

(1) Seriously Hindered (2) Somewhat Hindered (3) Borderline Support (4) Somewhat Facilitated (5) Greatly Facilitated

47) Rating of the TOC design to ensure easy information flow between BFA's and synchronization:

(1) Seriously Hindered (2) Somewhat Hindered (3) Borderline Support (4) Somewhat Facilitated (5) Greatly Facilitated

48) Rating of how the TOC design promoted BOS integration throughout the:
(mark one ☒ per row)

	Seriously Hindered	Hindered	Borderline	Facilitated	Greatly Facilitated
Planning					
Preparation					
Execution					

49) Rating of how the system design promoted efficient internal communication:

(1) Seriously Hindered (2) Somewhat Hindered (3) Borderline Support (4) Somewhat Facilitated (5) Greatly Facilitated

50) Rating of how the TOC system design promoted efficient total staff integration:

(1) Seriously (2) Somewhat (3) Borderline (4) Somewhat (5) Greatly

Hindered Hindered Support Facilitated Facilitated

51) Rating of the TOC system design to allow easy assimilation of audio data by the entire staff:
(1) Seriously Hindered (2) Somewhat Hindered (3) Borderline Support (4) Somewhat Facilitated (5) Greatly Facilitated

52) Rating of the TOC system design to allow easy assimilation of visual data by the entire staff:
(1) Seriously Hindered (2) Somewhat Hindered (3) Borderline Support (4) Somewhat Facilitated (5) Greatly Facilitated

53) Rating of the TOC system design to facilitate information being sent to the appropriate destination:
(1) Seriously Hindered (2) Somewhat Hindered (3) Borderline Support (4) Somewhat Facilitated (5) Greatly Facilitated

54) Rating of the TOC system design to allow the entire staff to monitor operational situations:
(1) Seriously Hindered (2) Somewhat Hindered (3) Borderline Support (4) Somewhat Facilitated (5) Greatly Facilitated

55) Rating of the ability for you to complete your tasks using automated tools:
(1) Seriously Hindered (2) Somewhat Hindered (3) Borderline Support (4) Somewhat Facilitated (5) Greatly Facilitated

56) Rating of the ability for you to maintain better situational awareness using the available automated tools compared to analog methods:
(1) Seriously Hindered (2) Somewhat Hindered (3) Borderline Support (4) Somewhat Facilitated (5) Greatly Facilitated

57) Rating of the ability for you to exchange information with personnel you need to colaborate with using the available automated tools:
(1) Seriously Hindered (2) Somewhat Hindered (3) Borderline Support (4) Somewhat Facilitated (5) Greatly Facilitated

58) Rating of the ability for you to exchange information with personnel you need to collaborate with based on the current TOC design:
(1) Seriously Hindered (2) Somewhat Hindered (3) Borderline Support (4) Somewhat Facilitated (5) Greatly Facilitated

59) Rating of the ability of digitization to provide adequate features for maintaining a COP with other personnel, even when face to face communications were not possible:
(1) Seriously Hindered (2) Somewhat Hindered (3) Borderline Support (4) Somewhat Facilitated (5) Greatly Facilitated

55) What are your top three suggestions to improve the usefulness of the CP:
a) _____
b) _____

c) _____

IV. SAFETY

1) Did you identify any TOC safety hazards (shortcomings)? [example: electrical hazards, equipment configuration/design, non secured items (loose), sharp edges]

☐ No ☐ Yes ☞ Please explain:_____

_____

_____

_____

V. HEALTH HAZARDS

1) Please identify any health hazards (example: noise level, exposure to chemicals, oxygen deficiency, heat/cold stress, work stress) associated with the CP (includes ABCS).

☐ None or Comments: _____

_____

_____

_____

VI. SAFETY / HEALTH HAZARDS -- COMMENTS

1) What are your comments concerning safety and health hazards while operating within CP.

☐ None or Comments: _____

_____

_____

APPENDIX C
Tables Of Questionnaire Results

Table C1:
Manpower/Personnel and Training

N=24

	Yes	No	Do Not Know	Chi -Square	Sig
Were there an adequate number of personnel available in your Command Post (CP) to perform operations including setup and breakdown?	33.3%	62.5%	4.2%	2.13	.79
Did you require personnel augmentation in order to perform CP operations including setup, breakdown, camouflage and security?	41.7%	41.7%	16.7%	0.06	.83
Were there enough ABCS personnel (manpower) in your CP to reconfigure and reactivate the workstation?	37.5%	41.7%	20.8%	0.05	.87
Were there enough personnel in your CP to prevent mission delays?	54.2%	25.0%	20.8%	2.58	.13
Do the personnel skills required to setup/breakdown the TOC necessitate a specific Additional Skill Identifier (ASI) or unique MOS?	16.7%	83.3%	0.0%	10.66	<.01
Did you receive formal training on this TOC configuration regarding setup and breakdown?	16.7%	70.8%	0.0%	8.05	<.01
Did you receive formal training on internal TOC layout?	16.7%	75.0%	0.0%	8.03	<.01
Did you receive instruction from your commander regarding interior layout for your specific Battlefield Functional Area?	41.7%	58.3%	0.0%	0.67	.78

Table C1:
Human Factors Summary
N=24

	Very Low	Low	Borderline	High	Very High	No Response	Chi-Square	Sig
The noise level of your work area while operating within the CP was:	0.0%	37.5%	45.8%	12.5%	4.2%	0.0%	20.24	<.01
	Very Poor	Inadequat	Borderline	Adequate	Excellent	No Response	Chi-Square	Sig
The intensity (brightness/darkness) of light in the TOC was:	0.0%	4.2%	4.2%	70.8%	20.8%	0.0%	41.65	<.01
	Excellent	Adequate	Borderline	Inadequate	Very Poor	No Response	Chi-Square	Sig
The view of the situational map from your work area was:	8.3%	29.2%	16.7%	25.0%	20.8%	0.0%	3.08	.47
	Yes	No				No Response	Chi-Square	Sig
Does the system design facilitate quick setup?	37.5%	63.5%					1.5	0.20
Does the system design facilitate quick breakdown?	33.3%	54.2%				12.5%	1.41	.22
	Seriously Hindered	Somewhat Hindered	Borderline Support	Somewhat Facilitated	Greatly Facilitated	No Response		
Rating of how the portability of the components of the TOC design system affects the mobility of the military	20.8%	37.5%	20.8%	16.7%	0.0%	4.2%	8.63	..07

unit:								
	Yes	No						
Did the physical dimensions of the system design provide adequate space for digital and non-digital equipment:	95.8%	4.2%					21.6	<.01
Did the physical dimensions of this TOC design provide adequate space for the number of personnel required for effective TOC operations?	83.3%	16.7%					10.7	<.01
	Seriously Hindered	Somewhat Hindered	Borderline Support	Somewhat Facilitated	Greatly Facilitated	No Response		
Rating of this TOC design to allow for optimal arrangements of equipment and personnel that facilitated the ease of access to information displays:	4.2%	33.3%	12.5%	45.8%	4.2%	0.0%	16.82	<.01
Rating of how the physical dimensions of this TOC design affected the efficiency of communications among personnel:	8.3%	20.8%	33.3%	29.2%	8.3%	0.0%	6.41	..17
Indicate how each of the following physical conditions affected C4IS operations: Ambient lighting	0.0%	0.0%	12.5%	70.8%	12.5%	4.2%	41.97	<.01
Indicate how each of the following physical conditions affected C4IS operations: Temperature	8.3%	16.7%	20.8%	50.0%	0.0%	4.2%	17.37	<.01
Indicate how each of the following physical conditions affected C4IS operations: Noise	0.0%	16.7%	29.2%	50.0%	0.0%	4.2%	22.54	<.01
Indicate how each of the following physical conditions affected C4IS operations: Ventilation	4.2%	20.8%	33.3%	33.3%	4.2%	4.2%	10.27	<.05
Rating of the modularity of the system design to allow for open TOC architecture to support the Commander's layout preferences:	0.0%	12.5%	29.2%	50.0%	4.2%	4.2%	20.29	<.01
Rating of the adaptability of the TOC system design to accommodate large screen displays and multiple displays:	4.2%	12.5%	12.5%	41.7%	29.2%	0.0%	11.00	<.05
Rating of the adaptability of the TOC design to accommodate horizontal and vertical map boards:	4.2%	12.5%	12.5%	62.5%	8.3%	0.0%	30.84	<.01
Rating of the flexibility and open architecture of the TOC design to affect the performance of tasks related to mission, enemy, terrain, troops, and time	4.2%	16.7%	20.8%	54.2%	4.2%	0.0%	20.15	<.01

available (METT-TC):								
Indicate how this TOC design impacted on effective C4IS operations related to METT-TC: Mission	0.0%	0.0%	20.8%	58.3%	12.5%	8.3%	27.63	<.01
Indicate how this TOC design impacted on effective C4IS operations related to METT-TC: Enemy	0.0%	4.2%	33.3%	45.8%	8.3%	8.3%	19.57	<.01
Indicate how this TOC design impacted on effective C4IS operations related to METT-TC: Troops	4.2%	4.2%	29.2	50.0%	4.2%	8.3%	20.48	<.01
Indicate how this TOC design impacted on effective C4IS operations related to METT-TC: Terrain	4.2%	20.8%	20.8%	41.7%	4.2%	8.3%	11.65	<.025
Indicate how this TOC design impacted on effective C4IS operations related to METT-TC: Time Available	12.5%	20.8%	16.7%	33.3%	8.2%	8.3%	4.58	.55
Rating of the physical characteristics of equipment and personnel arrangements in the TOC system to contribute to a safe working environment:	4.2%	4.2%	37.5%	41.7%	12.5%	0.0%	15.99	<.01
Rating of the TOC system design to employ concealment and camouflage techniques:	20.8	29.2%	20.8%	20.8%	4.2%	4.2%	4.04	.48
Indicate how this TOC design affected the ability to control: Noise	0.0%	25.0%	41.7%	33.3%	0.0%	0.0%	17.66	<.01
Indicate how this TOC design affected the ability to control: Lighting	4.2%	12.5%	8.3%	66.7%	8.3%	0.0%	33.07	<.01
Indicate how this TOC design affected the ability to control: Thermal	4.2%	29.2%	41.7%	25.0%	0.0%	0.0%	14.74	<.01
Indicate how this TOC design affected the ability to control: Physical TOC Evidence (Signature)	16.7%	33.3%	25.0%	16.7%	0.0%	8.3%	7.49	.14
Indicate how this TOC design affected the ability to control: Time Available	16.7%	25.0%	29.2%	25.0%	0.0%	4.2%	6.21	..19
Rating of the TOC system design to allow the staff to take measures to protect from surprise, observation, detection:	33.3%	16.7%	37.5%	8.3%	0.0%	4.2%	12.37	<.025
Rating of the TOC system design to allow the staff to take measures to protect form espionage, terrorism or sabotage:	16.7	8.3%	45.8%	16.7%	4.2%	8.3%	12.9	<.025
Rating of the TOC system design to allow the Commander to provide directions and management for the TOC	0.0%	12.5%	16.7%	50.0%	16.7%	4.2%	16.54	<.01

staff:								
Rating of the TOC system design to allow the Commander to obtain information on the mission, enemy forces, friendly forces, terrain, weather:	8.3%	8.3%	8.3%	45.8%	29.2%	0.0%	13.58	<.01
Rating of the TOC design to allow C4I accessibility from all TOC locations:	0.0%	4.2%	50.0%	25.0%	8.3%	12.5%	20.53	<.01
Ratings of the TOC system design to ensure that voice commands are easily heard throughout the TOC:	4.2%	25.0%	8.3%	41.7%	20.8%	0.0%	10.57	<.05
Rating of the TOC system design to ensure easy integration of ABCS and associated communication networks and nodes (e.g., LANs, WAN's, satellites, data facsimiles, etc.):	25.0%	12.5%	16.7%	29.2%	16.7%	0.0%	2.25	.96
Rating of the TOC system design to ensure the easy visual scanning of map boards at all locations:	20.8%	25.0%	12.5%	29.2%	12.5%	0.0%	2.68	.85
Rating of the TOC system design to ensure the easy and quick establishment of an integrated communication system:	4.2%	37.5%	20.8%	25.0%	12.5%	0.0%	7.67	.31
Rating of the TOC design to enhance the Commander's ability to observe the staff:	4.2%	20.8%	8.3%	50.0%	16.7%	0.0%	15.57	<.01
Rating of the TOC design to ensure that the Commander can observe the entire staff and implement risk management:	4.2%	29.2%	8.3%	50.0%	8.3%	0.0%	18.07	<.01
Rating of the TOC design to create an environment for the Commander to provide the staff with guidance and monitor activities:	4.2%	20.8%	4.2%	54.2%	16.7%	0.0%	20.15	<.01
Rating of the TOC design to allow the Commander to focus the activities of his staff:	4.2%	16.7%	25.0%	37.5%	16.7%	0.0%	7.24	.39
Rating of the TOC design to allow the Commander to always position himself in order to maintain an active command presence among the entire staff:	4.2%	4.2%	12.5%	54.2%	25.0%	0.0%	20.99	<.01
Rating of the TOC design to promote task sharing and teamwork among the battlestaff:	4.2%	16.7%	20.8%	45.8%	12.5%	0.0%	11.83	.08
Rating of the TOC design to promote workload distribution among the battlestaff:	4.2%	25.0%	20.8%	45.8%	4.2%	0.0%	14.32	<.05
Rating of the TOC design to promote prioritizing	0.0%	4.2%	41.7%	54.2%	0.0%	0.0%	32.15	<.01

actions:								
Rating of the TOC design configuration to permit teamwork and reduce workload:	20.8%	16.7%	25.0%	33.3%	4.2%	0.0%	5.57	.21
Rating of the TOC to promote staff workload sharing and collaboration:	8.3%	20.8%	29.2%	37.5%	4.2%	0.0%	9.63	<.0
Rating of the TOC design to allow BFA's adequate space to advise and assist the Commander:	4.2%	12.5%	12.5%	62.5%	8.3%	0.0%	27.67	<.01
Rating of the TOC system design to promote collaborative planning:	4.2%	16.7%	20.8%	50.0%	8.3%	0.0%	15.57	<.01
Rating of the TOC design to promote synchronization:	0.0%	16.7%	41.7%	33.3%	8.3%	0.0%	14.32	<.01
Rating of the TOC design to permit easy visual and auditory communication to integrate TOC personnel for planning and execution:	4.2%	20.8%	20.8%	37.5%	12.5%	4.2%	7.38	.21
Rating of the TOC design to provide adequate space for the assembly of staff members during wargaming:	16.7%	12.5%	25.0%	20.8%	16.7%	8.3%	1.25	.95
Rating of the TOC design to provide adequate space for supervision of staff during wargaming?	8.3%	12.5%	12.5%	45.8%	12.5%	8.3%	11.68	<.025
Rating of the TOC design to promote the development of an accurate common operating picture:	8.3%	4.2%	29.2%	50.0%	8.3%	0.0%	18.07	<.01
Rating of the TOC design to provide the staff an unobstructed field of view of situational maps:	4.2%	33.3%	20.8%	29.2%	12.5%	0.0%	9.50	.08
Rating of the TOC design to ensure easy information flow between BFA's and synchronization:	8.3%	12.5%	41.7%	25.0%	12.5%	0.0%	8.92	.18
Rating of how the design promoted BOS integration throughout the: Planning	4.2%	12.5%	20.8%	50.0%	4.2%	8.3%	17.49	<.01
Rating of how the design promoted BOS integration throughout the: Preparation	8.3%	12.5%	20.8%	58.3%	0.0%	0.0%	24.26	<.01
Rating of how the design promoted BOS integration throughout the: Execution	4.2%	20.8%	16.7%	50.0%	8.3%	0.0%	15.57	<.01
Rating of how the system design promoted efficient internal communication:	0.0%	25.0%	12.5%	54.2%	8.3%	0.0%	21.42	<.01
Rating of how the TOC system design promoted efficient total staff integration:	0.0%	25.0%	29.2%	41.7%	4.2%	0.0%	14.74	<.01
Rating of the ROC system	4.2%	16.7%	37.5%	37.5%	4.2%	0.0%	13.49	<.01

design to allow easy assimilation of audio data by the entire staff:								
Rating of the TOC system design to allow easy assimilation of visual data by the entire staff:	8.3%	12.5%	33.3%	45.8%	0.0%	0.0%	17.25	<.01
Rating of the TOC system design to facilitate information being sent to the appropriate destination:	4.2%	16.7%	25.0%	50.0%	4.2%	0.0%	17.23	<.01
Rating of the TOC system design to allow the entire staff to monitor operational situations:	4.2%	16.7%	29.2%	37.5%	12.5%	0.0%	8.50	.20
Rating of the ability for you to complete your tasks using the automated tools:	25.0%	20.8%	12.5%	33.3%	8.3%	0.0%	4.75	.57
Rating of the ability for you to maintain better situational awareness using the available automated tools compared to analog methods:	20.8%	16.7%	8.3%	45.8%	8.3%	0.0%	11.41	<.025
Rating of the ability for you to exchange information with personnel you need to collaborate with using the available automated tools:	20.8%	8.3%	33.3%	20.8%	12.5%	4.2%	4.46	.51
Rating of the ability for you to exchange information with personnel you need to collaborate with based on the current TOC design:	12.5%	8.3%	33.3%	37.5%	8.3%	0.0%	9.75	<.05
Rating of the ability of digitization to provide adequate features for maintaining a COP with other personnel, even when face to face communications were not possible:	20.8%	12.5%	16.7%	41.7%	8.3%	0.0%	8.08	.07
	Response	No Response						
What are your top three suggestions to improve the usefulness of the CP?	79.2%	20.8%						
	No	Yes						
Did you identify any TOC safety hazards (shortcomings)? [example: electrical hazards, equipment configuration/design, non secured items (loose), sharp edges]	58.3%	41.7%						

APPENDIX D

Questionnaire Comments

Soldier ID#	*Question#*	*Comment*
	6	**Were there an adequate number of personnel available in your Command Post (CP) perform operations including setup and breakdown?**
1	6	Too many things to do. We can't cover it all.
5	6	Our MTDE does not provide personnel to man the Planning Requirements of the TAC,
5	6	of TOC operations including the security requirements.
8		There were plenty of people to break down a normal brigade CP but there was too much
8		that contractors brought and we had to load.
10		In comparison to last year's NTC rotation, we lack in personnel and experience.
11	6	S-3 needs more soldiers. Make reserve slots and more active duty slots.
12	6	We are forced to argue with TOC staff, personnel from plans. Even then we are barely
12	6	properly.
14	6	We are short people and have been for a long time. Sometimes we have to do a lot more
14	6	kills morale and mission.
16		Require three persons to man all systems (FBCB2J, MCS, SINGARS) plus other
20		Need more authorization t brigade level or do not count reservist slot against active duty
22	6	Not close.
	7	**Did you require personnel augmentation in order to perform CP operations setup, breakdown, camouflage and security?**
5	7	All duties were conducted by the personnel assigned to the TOC.
8	7	We had all cells and all shifts up for days putting up and fixing camouflage and security.
10	7	Normally dayshift would setup TOC and nightshift sleeping quarters, however due to
10	7	had to pull from the night crew to setup TOC and cover down on security as well as
10	7	fundamental precautions.
12	7	There is no TOC security.
16	7	We needed it but didn't receive it.
20	7	Did not receive personnel.
22	7	No, we didn't get them. Often people worked two shifts.
23		Not manned to do guard, KP, camo net repair/adjustments and monitor radio, operate
23		senior NCOs ended up being RTD's operators instead of planning and supervising.
	8	**Were there enough ABCS personnel (manpower) in your CP to reconfigure and workstations?**
5		We have 3 personnel trained to operate two boxes.
8		The workstations are unstable and go down all the time. The contractors are only here
		we can't go into superuser and fix problems all night.
10		Most of the people in the TOC under this command are new but there are a couple of
10		assisted in reactivation. However, these were extra people to handle the particular
10		procedures.
12	8	We have a handful (2) who are proficient in running the systems. There is no depth.
13		Short one ABCS operator.
14		Sometimes when you needed them, they were not around.
18		Not enough operators available for work stations.
20		Not enough for personnel.
21		We didn't have enough trained operators for night and day shifts.
22	8	Often lost operators to work details, guard duty, and KP.
23	8	Not enough contractor support. Operators not allowed to reconfigure systems.

	9	**Were there enough personnel in your CP to prevent mission delays?**
3		Must stop in the setup to answer radios and questions.
5		But to run full up operation, it required our full MTDE allocation of personnel. Two at
5		Bde FSE two RTOs. Two AFATDS operators, one NCDIC, and Bde FSO.
10		But there are still the inexperienced that create a great time defect in comparison to
14		Well, yes, if you suck it up and drive on knowing what you got is what you got even
14		People to do your work.
16	9	As I stated in previous comment, the moment "sidebar" mission developed we were
16	9	people short. At times, an officer manned the SINGARS.
17	9	At times.
23	9	Skeleton crew because of guard/KP daily tasks.
24	9	We were not part of this last test.
	10	**Do the personnel skills required to setup/breakdown the TOC necessitate a specific Additional Skill Identifier (ASI) or unique MOS?**
4		Setup and breakdown of the TOC only requires a soldier's technical skills.
6		MOS not needed.
8		New people are forced to learn everything on the fly which is hard and creates stress.
8		TOC training. COMMS setup, camouflage, how to run wire and ground systems, how
8		affiliate DNVTS, what additional elements go into a CP, how to manage personnel with
12		There is a lot of training that operators must complete to be proficient.
13		No ASI or unique MOS needed to setup/breakdown TOC.
14		Not really but you can't be a rock if you know what I mean.
15		No, because we have not set it up enough to be quick. Once the TOC is setup a couple
15		quick.
16		The setup is simple and principal. Each section knows what needs to be done. Training
16		helped to bring all personnel to speed.
17	10	Yes and no. It is not a necessity but it would greatly improve TOC setup/breakdown
18	10	Everyone needs the training for TOC setup/breakdown.
19	10	As long as everyone knows what they are doing ahead of time and as long as there are
19	10	(one month qualified) to take care of the computers and electronics. On the other
19	10	(or group of people) knew how to do all the required tasks, then the setup/breakdown
19	10	smoother.
20	10	Each TOC setup will be different.
23	10	Basic NCA's and soldiering tasks for those in TOC.
	13	**Did you receive instruction from your commander regarding interior layout for your specific Battlefield Functional Area?**
3	13	Did the layout as the CDR would have wanted it.
5	13	As we developed the layout of the TOC, the Bde CDR and XO clearly laid out the Form
5	13	each BOSS would interact within the TOC.
6	13	All we have is our vehicle, table and three cars.
7	13	Our interior layout consists of only a table.
8	13	We are told how to pack the vehicles but as far as radios and tables are concerned we
9		I was lied to by my chief commander. I was told I was only going to out here 5 days and
9		computer.
10		BFA was laid out from previous experience.
12		The setup is constantly changing.
14		But as we got out, we go no equipment.
15		Almost too much.
20		Hide excess equipment.
21		There are too many ports.
22	13	Hide excess equipment.

	17	**Does the system design facilitate quick setup?**
3	17	Too many cables or fasteners running through or over the floorboards.
6	17	We have SICPS and circus tents (they are not meant to be put up together).
7	17	With setting up two tents (custom tents) plus two SICPS, plus gutters/"Custom Tents" and
7	17	gutters leak when it rains.
8	17	We have to put down floor boards then setup a tent that nobody had seen and only goes
8	17	special way with inadequate labeling.
9	17	There is too much useless stuff mostly concerning appearance. In a combat situation
9	17	jump in a hurry, maybe then sucking up to the VIPS will take less time.
10	17	Any TOC system design should facilitate quick setup. We will get there with time
12	17	There is a lot of integrate wiring and delicate handling for certain equipment.
13	17	There is a lot of cable to be run in addition to normal setup.
14	17	With the proper number of people, I think so.
16	17	The large setups were quick because it was as big as regular four setups.
17		Takes longer then SICPS but is bigger.
20	17	Too many parts(fasteners) , small and large.
23	17	Plenty of room.
	18	**Does the system design facilitate quick breakdown?**
3	18	Only certain number of personnel trained to breakdown certain system or systems.
5	18	There are a number of cables that are required to run from each vehicle to connect intra-
5	18	inter-TOC connectivity. Also a number of power and audio/video/LAN cables required
5	18	feeds to the CIC and intra-TOC communication system.
6	18	Not sure – have not done breakdown yet.
7	18	We haven't taken down the "custom tents" yet.
8	18	It is not modular, each section is designed to pack itself up and move and help everyone
8	18	done. Right now we have to wait on the slowest man to bring down the tents and floor
9	18	As I explained above, there are too many extras.
12	18	It is very complicated.
16	18	Ask me at the end of April.
17	18	A lot of wires and common stuff takes times.
20		Too many parts, small and large.
23		TOC is too big.
5	18	Same reason as setup. A LOT of cables to recover.
	20	**Did the physical dimensions of the system provide adequate space for digital and digital equipment?**
8	20	The tents are plenty big enough but they need clips or bars to run wires.
9	20	Equipped.
10	20	But is very awkward to install internal wiring.
14	20	There is enough room.
17	20	There was plenty of space for all of the equipment.
	21	**Did the physical dimensions of this TOC design provide adequate space for the of personnel required for effective TOC operations?**
6	21	Not for the BUB (Battle Update Briefings).
7	21	For a BDE TOC, no one with the amount of personnel present at the BUB.
9	21	There is plenty of room for normal operations, however, when giving tours of the TOC to
9	21	from world university, some which are enemy countries, things did get a little tight.
14	21	Yes.
16	21	We are using too large 4F tracks in a briefing area. There are two regular SICPS on the
17		TOC was big enough to hold all personnel.
22	21	C2Vs and 1068s are too cramped.

27 How did ventilation affect C4IS operations?

8 Temperature is something soldiers deal with. Lighting is okay but if a TOC is quiet that
8 22 isn't getting around like it is supposed to.

44 What was the rating of the design to allow the staff to take measures to protect
26 **observation, and detection?**

2 The size makes it easier to see.
3 **27** Too large and takes up plenty of time setup and tear down.
5 Availability of personnel assigned to the TOC. Not enough people to perform TOC
5 Boxes and radios) and provide adequate security.
7 We have a SCAR but with all of the contractors we can't control it completely and without
7 our systems will not work.
8 Well, the new tents have a higher profile which is bad and we have to put up camo net
8 which stands a chance of blowing over easier. Not to mention, the corner dimension
8 light which is bad for discipline.
9 Camo net takes too long to setup.
10 Only three windows are present. TOC concealed light during evening Ops but during day
10 say borderline support.
12 The TOC is very resource intensive.
13 ALL BFA sections within the TOC are setup in a way to assist each other and share info.
14 Well, we have C2Vs that would probably be fine vecause they were made for being
14 this big camo net that in this that we are in, hinders movement and jumping time which
14 A camo net in this age is useless with today's technology.
15 It is a very high TOC. It could be lower and still work fine.
16 The size is difficult to conceal which makes it impossible to movement of area in case of a
16 attack. Laying automated systems out of the tracks makes it virtually impossible to
18 Not enough personnel for different types of guards.
19 Anytime you have an element this big (TOC), the enemy will be able to identify it unless
more natural cover and concealment.
21 The TOC is so big that concealment is almost impossible.
22 Two-toned colors.
23 Again, TOC is too big. Size of camo net makes it obvious it's a large building division CP.
23 Generators, easy to move up on to observe.

47 What was the rating of the TOC system design to allow the Commander to obtain the mission, enemy forces, friendly forces, terrain, and weather?

3 Plenty of new equipment (toys) but still relying on old method of obtaining info., radios.
6 The systems are down or cannot communicater with each other.
7 Need ATTCS systems to function properly before deployment not during.
8 Well, we have a huge bridge and a map. There isn't much info that we can't fit up there.
12 The large selections are a great tool for monitoring information from all ATCCS systems.
14 It's good.
19 The command and control is made easier by the layout in technology.
20 Systems unreliable as of right now.
21 Had a good view of all systems on LSO and could get the information he needed.
23 Large enough to accommodate maps, large screen TVs, etc.
24 The one map load gets crowded.

52 What was the rating of the TOC design to ensure the easy and quick establishment establsihment of an integrated communication system?

5 Relates to FHMUX

58 What was the rating of the TOC design to promote task sharing and teamwork battlestaff?

3 Battlestaff positioned further away from sections (ATTCS devices) to maintain positive
3 Lane as well as helping key players.
5 Biggest drawback is the FHMUX . With this we push up to 4 radios through one antenna.
5 reduces the range of both voice and digital communications.
8 All the TOC cells are shoved away in C2Vs. This means nobody can see us and we can't
8 commander is situated with his back to us. So we get no safety words and we are all
8 vehicles.
9 Although teams work in a big part of the TOC operations, it seems to be more forced on
9 rather than designed that way.
15 It's very large.
16 The CDR has not spent a lot of time at this loca. The Battle CPT seems to relay info
16 Battle NCO ha an understanding of this task.
18 Not enough personnel from each of the sections. Personnel had different missions to
20 Not enough room for all of staff and current TOC layout.
21 All staff is together so they work together.
22 Good vertical movement but not good horizontal movement.
23 BFAs are too spread out- ATTC's operators inside C2Vs have "cave mentality." Tends to
23 cross talk among BFAs.

81 What are your top three suggestions to improve the usefulness of the CP?

1 No KP. No camo net.
3 Improved light sets. Too many small pieces of equipment (cotterpins) are easy to loose.
3 Ceiling too high.
5 Get the CTP function to work. Provide ability to share large amounts of data (OPORD) to
5 a paper and a visual. Reduce the cable requirements to provide feeds into CIC, Intra-
5 Inter-TOC.
8 Quit putting so much stuff in at one time (its overloaded). Train more (soldiers don't know
8 Ask the soldiers what they need. Don't buy something that a salesman told you was
8 fix it to fit soldiers. Have them design it usefully.
9 Concentrate on the ability to jump quicker. Leadership using common sense would help
9 Sufficient amount of personnel to operate the TOC and all the other tasks, i.e., guards,
9 other data that take away from operation personnel.
10 Needs more convenient transport/portability is very cumbersome, better support for
10 ventilation, better sealing, i.e., waterproofing.
11 Get rid of camo net, get rid of TAVs, get rid of SICCPS.
12 Simplify the wiring, a common wire, improve compatibility of ATTCS; soft light.
13 Gutters need to be longer and add snaps to match the roof, the doorwalls to match tent,
13 (up and down) or ends for water run off.
14 Required people, contractors when you need them.
15 Make the side poles adjustable, camo the outside of tent, pad in light hangers.
16 Increase personnel strength at (MTOC), increase training for personnel/cross
16 Automated systems throughout.
17 Adequate number of personnel.
18 More personnel/more operators for work stations, assigned specific duties, more
18 hand.
20 Silencer on generators, large tent to accommodate more personnel for battle update
21 Make smaller, quicker to set up tents, keep as many things in vehicles, less cabling.
22 Open up the central floor more-like a pit, bleacher seats on each side-better flow in the
22 actually located. 60K generator needed. We need more power for this much draw.
22 also 60K is quicker.
23 Maker smaller. Move Engineer BN TOC out of Bde TOC. Get operators out of the C2Vs-

23		analyst to lead interface.
24		Listen to the lower enlisted. They good ideas. Stick with one TOC layout until after NTC.
	82	**Did you identify any TOC safety hazards (shortcomings)?**
2	38	Walking on tents to put up camouflage. Some soldiers slipping could have been hurt.
5	38	The number of cables; power, communications, and data required to establish has a
5	38	when introduced into inclement weather.
6	38	People tripping over the floorboards and broken palettes outside the TOC.
7		Without level ground the use of floorboards and pallets is a hazard. Also, putting camo
8		To put a camouflage net on the TOC the soldiers had to climb on the tents which were
8		hold shifting weight.
9		Loose floors, electrical wires spanning long distances, rain leaking in on electric
9		being assembled at night, fumes inside the TOC.
16		Wiring is all over the AO. This causes two hazards: electrical and obstacles.
20		Electrical cords need to be kept on floor to prevent shorts when it rains. Not enough
20		lights.
21		To set up camo you have to walk on the tent.
22		Power lines could be setup so as not to run across the TOC.
24		Personnel on top of the circus tent too help put como net.
	83	**Were there any health hazards associated with the CP (including ABCS)?**
2		The exhaust from C2V being side by side makes it hard to refuel. The exhaust blows on
2		driver's door.
3		Cables, some power- running back, across, over and on sides of TOC walls.
5		Carbon monoxide created by all power generation devices required to power the TOC.
7		Without proper ventilation in the TOC, it is a health hazard.
8		Work stress: the ABCS does not work. They constantly break or don't do what the
8		When they breakdown, the soldiers get blamed and chewed out but know one cares
8		In the TOC because they are all totally fed up with "BS" systems that don't work and
8		a contractor every 15 minutes.
9		Stress can build up, especially for lower enlisted who when things go wrong, they seem to
9		the leaders.
10		Only complaint is that tent holds both heat and cold. If you can create a portable device
10		wonderful.
12		High noise level, bright lights, TOC exhaust fumes.
14		Have to due with shortage of personnel, too many missions and not enough people – ask
16		Just the usual that comes from working in the military. Stress level is higher because of
16		BDECDR is determined to go to NTC and win the fight digitally.
19		Noise level could be lowered.
20		Noise level, exhaust fumes from C2V flow into TOC, not enough ventilation.
21		The carbon dioxide from the vehicles stayed trapped in the TOC due to lack of ventilation.
22		Noise level equals high, oxygen is not good, ventilation bad.
23		Exhaust froc C2Vs PPU gets into TOC.
	90	**What are your comments concerning safety and health hazards while operating**
5		Also, Elctro-magnetic signatures generated by the power cables, added screens, etc.
6		Floor boards and palettes.
7		Fumes from gas and fire hazards.
15		Need lightning rods.
20		Dust from cleaning the floors to keep TOC neat.
21		Implement ventilation system.
22		Fumes prevalent.

APPENDIX E

Definition of Terms (English & English, 1958)

Scale--unit of light measurement as indicated on the GOSSEN LUNA-PRO light meter.

Candle (candle power)--the unit of luminous intensity of a source of light. It was originally measured by comparison with a standard international candle. Since 1948, a candle is one-sixtieth of the luminance per square centimeter of a complete radiator at the temperature of solidification of platinum.

Foot-Candle--a unit of illuminance or illumination equal to that produced by a uniform point source of one standard candle on a surface every point of which is one foot away from the source.

Lux (meter candle)--the illuminance of a surface one square meter in area receiving uniformly distributed flux of one lumen; or the illuminance produced at the surface of a sphere having a radius of one meter by a uniform point source of one international candle situated at its center.

Lumen--the unit of luminous flux. It is equal to the flux through a unit solid angle from a uniform point source of one candle, or to the flux on a unit surface all points of which are at unit distance from a uniform point source of one candle. It is the strength of the light energy. -- Symbol, L.

Four related terms may be compared:

1. *Luminance*--the light energy emitted, reflected, or transmitted; the luminous flux emitted per unit solid angle and unit projected area of source. This was formerly called photometric brightness. It may be measured in lamberts of millilamberts.

2. *Illuminance*--is the strength of light arriving at, or incident to, a surface; it is what the layman calls the illumination of the surface. Its measurements are in plane geometry terms.

3. *Luminosity*--the brightness-producing capacity of light. Luminosity is not a function of the physical intensity of the light (i.e., of luminance) but of that light under all the prevailing physical conditions (distance, grain of the light surface, translucence of the medium, etc.). It is luminosity, not luminance, which is the physical correlate of brightness. It is measured by the ratio of photometric quantity to radiometric quantity, e.g., lumens (photometric) per watt (radiometric).

4. *Brightness*--is the psychological attribute of color or light as it is perceived. Its physical correlate is luminosity.

NOTE: If a light meter is not available that measures foot-candles or Lux then an ordinary photographic light meter can be used by converting a combination of (1) an arbitrary film sensitivity (ASA rating) with its associated (2) aperature (f-number) and (3) shutter speed to light measurement in Lumen/Meter^2. These measurements can be computed using a formula presented by Nilsson (1981) (i.e., Lumen/meter^2 = (215.3 x f number^2) / ASA x shutter time in seconds).

APPENDIX F

General Illumination Levels and Types of Illumination for Different Task Conditions and Types of Tasks (Van Cott & Kincaide, 1972)

Task condition	Type of task or area	Illuminance level (Ft.-c)	Type of illumination
Small detail, plus low contrast, prolonged periods, high speed, extreme accuracy.	Sewing, inspecting dark meterials, etc.	100	General supplementary, e.g., desk lamp.
Small detail, fair contrast, speed not essential.	Machining, detail drafting, watch repairing, inspecting medium materials, etc.	50-100	General plus supplementary.
Normal detail, e.g., prolonged periods.	Reading, parts assembly; general office and laboratory work.	20-50	General, overhead ceiling fixture.
Normal detail, no e.g., prolonged periods.	Washrooms, power plants, waiting rooms, kitchens.	10-20	General, random natural or artificial light.
Good contrast, fairly large objects.	Recreational facilities.	5-10	General.
Large objects.	Restaurants, stairways, bulk-supply warehouses.	2-5	General.