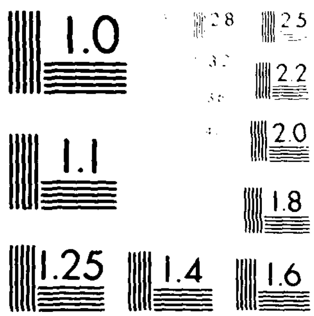
AD-A090 362 ARMY RESEARCH INST OF ENVIRONMENTAL MEDICINE NATICK MA F/G 5/9
SIMULATED, SUSTAINED-COMBAT OPERATIONS IN THE FIELD ARTILLERY F--ETC(U)
JUN 80 L E BANDERET, J W STOKES

UNCLASSIFIED NL

1 OF 1

AD A
090362

END
DATE
FILMED
11-80
DTIC



MICROCOPY RESOLUTION TEST CHART

JUN 1980

SIMULATED, SUSTAINED-COMBAT OPERATIONS IN THE FIELD ARTILLERY FIRE DIRECTION CENTER(FDC): A MODEL FOR EVALUATING BIOMEDICAL INDICES (U)

LOUIS E. BANDERET, Ph.D.
JAMES W. STOKES, LTC, MC.
RALPH FRANCESCONI, Ph.D.
DENNIS KOWAL, CPT, MSC.
US ARMY RESEARCH INSTITUTE OF ENVIRONMENTAL MEDICINE
NATICK, MA 01760

When military biomedical research addresses practical problems, the scientist must evaluate if biological and behavioral phenomena have real-world consequences for military planners and users. The military scientist must scale and translate his findings into a suitable framework so military planners can anticipate how such consequences will degrade (or sustain) the operational effectiveness of military personnel. In evaluating conditions which affect human performance, the scientific literature (1-3) indicates the importance of task, personnel, and organizational variables. These include: task complexity, feedback, pacing, level of training, intrinsic task interest, experience, motivation, and social factors. Such variables are considered critical determinants of performance capability under a variety of conditions. Furthermore, in both modern industrial society and in the Armed Forces, tasks are increasingly organized around teams rather than individuals (5). In the military community, concerns are often expressed as to the generality and predictive validity of past studies which have not included variables inherent in many military tasks.

To address these issues and provide a framework for communicating research results to the military community, the Field Artillery fire direction center (FDC) was selected by the US Army Research Institute of Environmental Medicine (USARIEM) as a "model" team for study. It was postulated that these issues could be addressed in a laboratory simulation which would use actual Army teams performing their normal functions. This would permit control and replication of environmental and situational conditions and measurement and correlation of mission effectiveness, behavior and biological processes (3,4). This approach capitalized on pre-existing training, professional pride, social support and military task organization. Such factors are critical in the study of group task performance, the contribution of individual performance to system (team) output (3,4) and physiological and psychological responses to stress (5).

The FDC team seemed well-suited for scientific study and laboratory simulation since 1) FDCs are common and critical to successful ground combat operations, 2) FDC teams are located immediately behind the FEBA and are exposed to most extent stresses, 3) FDCs include tasks common to other command/control and communication elements, 4) Detailed scenarios can be developed to provide calibrated performance demands, 5) FDC tasks provide quantifiable measures of both individual and team performance, 6) The compactness of FDCs allows collection of a wide range of biomedical and psychosocial data, 7) Many variables which influence performance are inherent in FDCs, and 8) FDCs provide a performance paradigm with operational criteria, recognized by the military community, with which various data arrays can be correlated.

FDC TASKS & ORGANIZATION

In the Field Artillery, the FDC is a service center which receives requests from various groups who require artillery shells to hit target areas. These targets are typically kilometers away and out of view of the guns. In the US Army (Artillery battery level) a team of 5 to 7 individuals process these requests. Non-computerized FDCs have existed since World War I and have evolved to insure that performance is robust to adverse conditions. Roles, tasks, communication sequences and content, error detection and resolution capabilities, information readback procedures, etc. are well specified and practiced. To understand variations in system output, individual task contributions and interactions can be analyzed (6,7). Many FDC tasks are similar to classical performance tests. Sometimes FDC tasks are embedded in contexts which limit interpretation, but they can be compared with the scientific literature.

METHODS

STANDARDIZATION OF TASK DEMANDS

Much precision of conventional laboratory paradigms was applied to the complex mission demands of the Field Artillery to document FDC performance and to reduce extraneous variance. This methodology was incorporated into a detailed script ("scenario") of radio messages which provided the task demands, as well as the supporting documents, e.g. map overlays and unit SOP. The scenario represented a tactical battle played on 1:50,000 scale maps and followed current doctrine for the light infantry with armored cavalry opposing a well-equipped screening force. Tasks demands were communicated to the FDC over three simulated radio nets; other roleplayers provided the telephone communications of the nearby gun crews and controlled the guns' sound effects.

To permit performance assessment with time the scenario was organized into equivalent 6 h epochs of mission demands. In each 6 h, events of differing importance, complexity, and urgency, requiring different individual and team responses, recurred frequently to permit event pooling for analysis of performance data. Some mission demands included: 1) Unplanned Missions -- Calls for Artillery fires on a target which were often followed by several subsequent adjustments, i.e., repetitions with small variations. 2) Preplanning --These tasks were initiated by the receipt of encoded preplanned target messages. All team members were involved, but for most delayed responses were required. 3) Prioritizing -- At any time, 2 of 16 preplanned targets were designated as having priority to emphasize that an especially rapid and accurate response might be required on these targets. 4) On-call Missions -- These demands were calls for Artillery fires on preplanned targets. Typically, they occurred at least 15 min after receipt of encoded preplanned target messages. 5) Revising --These initial 12 preplanned targets were encountered at the beginning of each 6 h epoch. Task demands differed somewhat from those of preplanning. The targets were preplotted on the chart sheets so the chart operators did not have to plot them nor did the radio operator have to decode them. 6) Updating --Updating should have occurred about 150 min into each epoch. It was to improve ballistic correction factors on 12 preplanned targets. 7) Multiple Mission Sequences --Periods of intense fire mission activity included: unplanned missions, on-call missions, non-standard missions, adjusts and shifts. 8) Lulls -- These were two 10-12 min intervals in which no new mission demands were sent to the FDC although irrelevant radio traffic continued. These events created a standardized setting, embedded among other demands, where social interactions might be more likely to occur. Such intervals could also be used to complete prior preplanning activities.

EXPERIMENTAL DESIGNS

Two designs were utilized. They differed in number of sustained challenges and their durations. Design I had a single 86 h operational challenge; whereas, Design II had two 38 h challenges separated by a 34 h rest interval. Both designs had identical, pre-challenge familiarization and training trials. Design I was essentially an "open ended" challenge since 86 h was judged to be beyond the limits for sleep deprived subjects to perform such cognitive tasks. Design II was to evaluate the FDC model in a repeated-measures design.

SUBJECTS & SIMULATION FACILITIES

The 5-man, FDC teams were males aged 18-24 and fully informed volunteers from two battalions of the 82nd Airborne Division. These teams used manual fire direction procedures exclusively, without the assistance of digital computers. Manual FDC equipment was assembled in a tent inside a 6.1 x 2.7 x 2.4 m climate-controlled chamber at USARIEM. Temperature was maintained 20-24°C, relative humidity 35-50%, and lighting was superior to field FDCs for continuous videotaping. Each subject wore a microphone and transmitter for individual voice reproduction, a physiological cassette recorder, wrist- activity sensor, ECG electrodes and, in some instances, EEG electrodes. Speech from each field radio, the FDC-gun telephone line, and from each FDC team member, as well as a time code, were recorded on separate channels of an audio recorder for post-study analyses.

SIMULATION PROCEDURES

All teams received a 5 h orientation followed by 3 days of simulation training (8 h/day) at the scenario work load used subsequently. Teams 1 and 4 then underwent a single challenge which they were told could run 86 h. Teams 2 and 3 underwent two 38 h challenges separated by a 34 h rest; they were told each challenge would run 36 to 42 h. All subjects were instructed not to set shifts or withdraw to sleep. Teams 1 and 4 received no instructions about job rotations; whereas, Teams 2 and 3 were instructed not to rotate jobs. In the simulation, each team was challenged by the scenario demands described previously. Performance-contingent, positive and negative feedback for accuracy and timeliness were given to the FDC from simulation roleplayers. During the simulations, FDC teams did not physically move the FDC, erect camouflage, or dig emplacements. All operational challenges began at 7 a.m. Every 6 h during a simulated tactical move, approximately 48 min were spent in non-operational, administrative activities. Self-report questionnaires were administered, urine and sometimes blood samples were collected, electrodes and instrumentation were maintained by "field medics" and meals were eaten.

PERFORMANCE ASSESSMENT

Performance indices were derived for system (team) performance. Post-study, accuracy and timeliness data were scored from audio recordings. Accuracy deviations, i.e. errors, were defined as the algebraic difference (in mils) between each FDC team's firing data and the correct solution as computed manually by the Department of Gunnery, USAFAS. Timeliness was the latency between mission input and the team's output.

INTERACTION ANALYSES

Interaction Process Analysis (IPA) by R.F. Bales assesses the quality of interactions occurring in a group (8). The FDC studies provided a unique opportunity to evaluate this non-invasive technique in small Army teams during acute exposure to situational stress and fatigue and to relate IPA trends to operational changes. In IPA, all verbal utterances are divided into communication units (CU). A CU is a group of sounds, words, gestures, etc. that conveys a single thought or action. Each CU is assigned to 1 of 12 categories based on the predominant quality of the interaction.

The FDC teams differed from many of the groups studied by Bales. Since the FDC's highly specified tasks, roles, and task organization generated many task communications which were standard in content and their time sequencing, an additional category, i.e., Task SOP, was specified for the FDC analyses. This category was for those CUs which were formal communications in the standard, sequential process of computing and transmitting ballistic data. Task SOP CUs only included standard communications about task or mission.

In the analyses, each team member's vocalizations during the two 12-minute lulls were transcribed from audio records and arrayed in parallel against a common time line. All verbal utterances were divided into CUs and all Task

SOP CUs were identified. All remaining CUs, i.e. All Other CUs, were identified and classified into one of Bales's categories. The sender and receiver for each CU were also specified. All information was formatted and encoded for automatic data processing. Video records were viewed prior to scoring each lull.

In the data reduction, group functions were computed for Teams 1, 2 & 4 (Team 3 is in progress). Each function represented the contributions of all 5 members. All CUs were categorized as Task SOP or All Others. To show the relative proportion of each a ratio was calculated:

$$\text{Task-Oriented Ratio} = \frac{\text{No. Task SOP CUs}}{\text{No. All Others CUs}}$$

RESULTS & DISCUSSION

OVERVIEW

Other investigators collaborated in the design and conduct of the study, but only selected data obtained by USARIEM investigators will be presented. The teams differed substantially in organizational style, social history, prior experience, and mastery of the simulated mission demands. Generally, Teams 1 and 4 showed less initial mastery and greater performance changes over time (Design I). All teams responded to the competitive challenges and became quite involved with the simulation (6,9).

Team 1 withdrew from the study at 7 a.m. after 48 h. A chart operator appeared especially sleepy after 42 h, choose to terminate, and the officer decided that the team should leave together. Team 4 withdrew voluntarily at 4 a.m. after 45 h. The younger enlisted personnel had little field experience and were very fatigued. The officer was also fatigued from his continuous supervision but persevered until his sergeant prompted him for the decision to stop. Both teams made several errors which "endangered" friendly troops; they had also become deficient in their preplanning and prioritizing. Team 2 showed some deterioration in the second challenge; three team members had slept very poorly the previous evening. Team 3 completed both 38 h trials with little performance deterioration. After 6 h of the second trial, a chart operator terminated; the remaining four continued. They had slept well in the interim.

SYSTEM OUTPUT: ACCURACY

For all teams, accuracy of firing data for unplanned missions was generally maintained even until termination. In contrast, accuracy of firing data for pre-planned targets fired upon during on-call missions was less for all teams. Accuracy deteriorated with time in Teams 1 and 4; they showed increased 7-14 mil errors. These usually involved omissions of correction factors in speed-accuracy tradeoffs. Generating preplanned target data required increased processing compared to unplanned missions. In addition, negative feedback criteria for on-call missions were more demanding, e.g.

199

20– 60 vs 60-180 sec. Teams 2 and 3 showed some variability in on-call mission accuracy; no progressive deterioration was evident.

SYSTEM OUTPUT: TIMELINESS

Although accuracy for unplanned missions was generally maintained, timeliness suffered in all but one team. Latencies for the subsequent adjustments increased more than 35% from initial values (approximately 30 sec) during sustained operations for Teams 1, 2, and 4. The within- team differences between initial and final 6-h performance latencies were statistically significant ($p \leq 0.05$ for Teams 1 and 2; $p \leq 0.01$ for Team 4). Video review confirmed that speed was sometimes sacrified for accuracy through increased individual latencies and double-check procedures. Such increased latencies have tactical significance since they would result in reduced effectiveness of Artillery fires on battlefield targets. This would increase FDC and battery vulnerability.

Timeliness, as well as accuracy, for on-call missions against preplanned targets suffered in Teams 1 and 4. Initial median latencies, e.g. 8-10 sec, increased >400% after 42 h in Team 1 and 50-400% after 30 h in Team 4 ($p \leq 0.01$). Teams 2 and 3 responses to on-call missions were less varied; Team 2's responses increased 30-60% from 18 to 30 h of the second challege ($p \leq 0.05$).

In responding to on-call missions against preplanned targets during the multiple mission sequences, Teams 2 and 3 showed some increased variability and latencies. In contrast, the quick responses to be achieved by preplanning deteriorated markedly in Teams 1 and 4 in those very situations where responsiveness was tactically most crucial. For Team 4, the 300-700% increases began after 24 h but recovered slightly after 36 h. In Team 1, increased latencies (40-300%) occurred from 6-30 h. After approximately 45 h, (0215 and 0400 a.m.), latencies increased 10-12 times from initial values. It is evident a median response >300 sec to deliver what Artillery doctrine requires in <20 sec was a marked change in operational efficiency. Such delays would have serious consequences in combat where rapid delivery of preplanned Artillery fires is essential to suppress hostile, wire-guided weapons.

Preplanning is intended to generate firing data for a preplanned target and send it to the guns before an on-call mission occurs. If preplanning was achieved, response latencies were minimal. If not, data computation was required "on the spot", increased latencies resulted, and teams were more likely to make errors in haste (or through deliberate omissions) as they attempted to respond quickly.

SYSTEMS OUTPUT: PREPLANNING & PRIORITIZING LATENCIES

Examining the efficiency of preplanned target processing activities, (i.e. preplanning, prioritizing, revising, and updating) suggests how the observed differences in team effectiveness in responding to on-call mission events occurred. It has the advantage of assessing risk of serious mission failure for the total population of preplanned targets. Operationally, preplanning required processing target messages and sending the firing data for each target to the

(200)

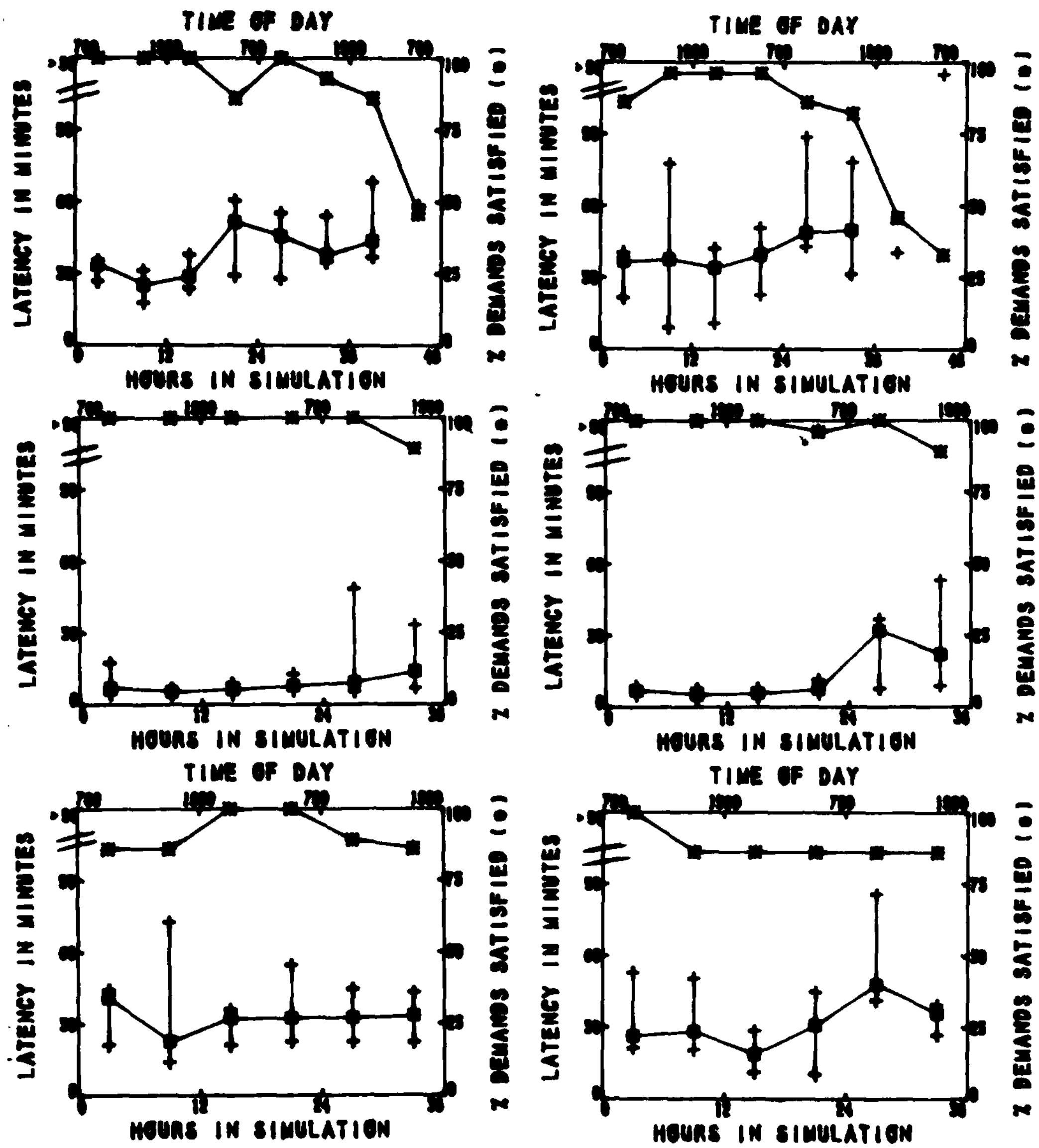


Figure 1. Preplanning latencies for Teams 1 (top left), 4 (top right), 2 (middle) and 3 (bottom) are shown as a function of h in the simulation. The squares, with lower and upper points, indicate the 50, 25, and 75th percentiles, respectively. Values plotted above the break on each left ordinate were >90 min. Also shown are the percent preplanning demands satisfied for each 6 h.

(201)

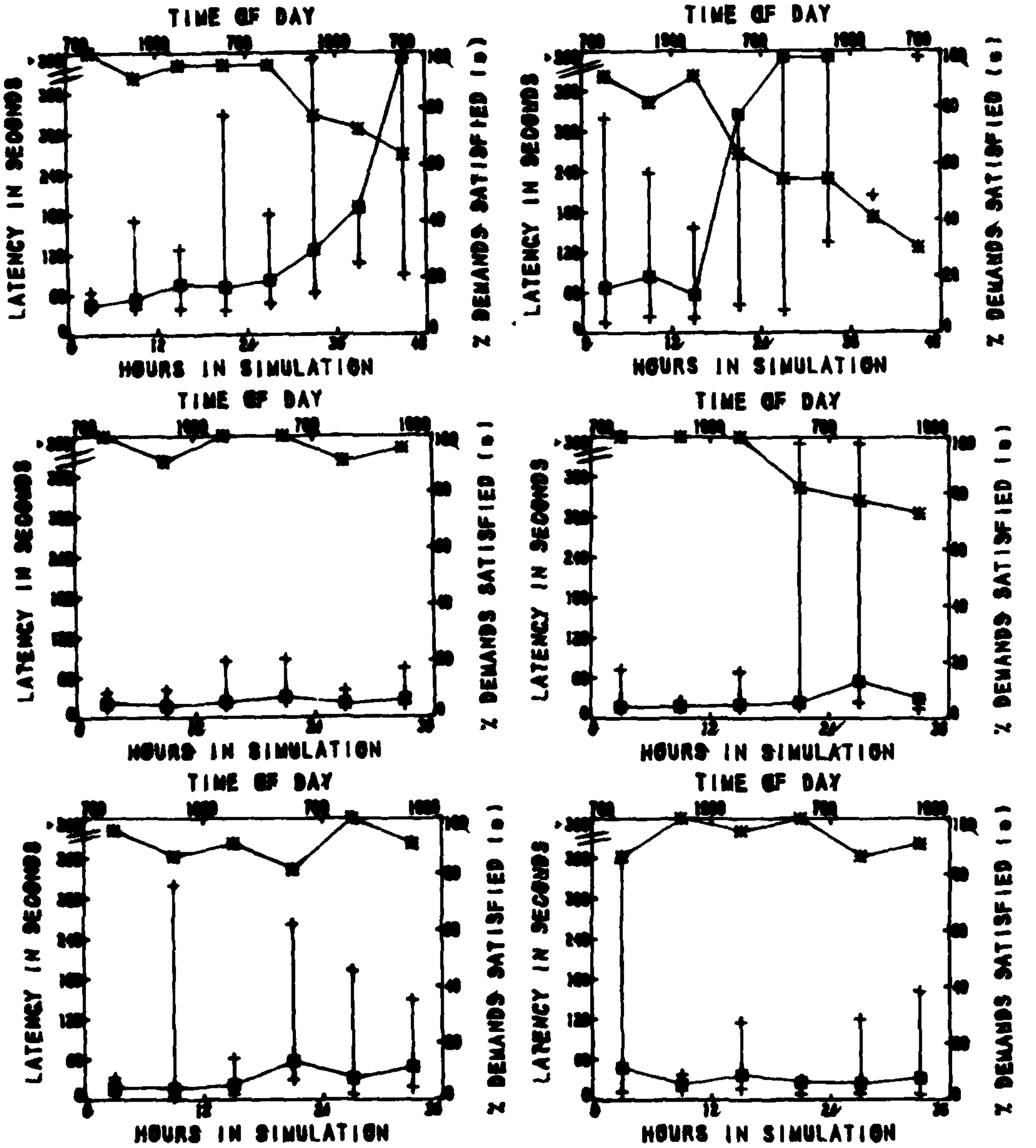


Figure 2. Prioritizing latencies for Teams 1 (top left), 4 (top right), 2 (middle) and 3 (bottom) are shown as a function of h in the simulation. The squares, with lower and upper points, indicate the 50, 25, and 75th percentiles, respectively. Values plotted above the break on each left ordinate were >360 sec. Also shown are the percent of prioritizing demands satisfied each 6 h.

guns as soon as possible. Preplanning involved all members; each had to complete his work on a target before another could proceed (serial processing). Hence, individual tasks were delayed. Team members had to schedule time to complete these tasks amidst "breaks" and other demands. Unless completed quickly, other scenario events would inevitably interrupt processing.

Preplanning latencies for the four teams are shown in Figure 1. Teams 1 and 4 showed increased latencies after 18-24 h; these increases were 30-70% greater than initial values. After 36 h performance was characterized predominantly by a failure to process several preplanned targets. Team 2 was very proficient; their latencies were approximately 25% those of other teams. Latencies of teams 2 and 3 did not change during the first 38 h challenge, although processing for team 2 was more varied after 24 h. During the second challenge of Teams 2 and 3 processing times increased after 24 h. Hence, the observed loss of effectiveness in responding to on-call missions (single and multiple missions sequences) in Teams 1 and 4 resulted from failure to preprocess data. Decreased accuracy resulted largely from speed-accuracy trade-offs or from lapses due to haste.

Figure 2 shows the prioritizing aspect of preplanned target processing. This task involved specifying to the guns which preplanned target was of greatest importance to the forward observer and calling ballistic data to the guns, if not communicated previously. Prioritizing emphasized some preplanned targets as being more important than others. Teams 1 and 4 showed increased latencies for prioritizing. Changes, 200 to 600% greater than initial values, were evident after 18 h in both teams. Teams 2 and 3 were more proficient and stable in their prioritizing, although some periods were characterized by increased variability. Consistent with the preplanning trend, Team 2's prioritizing was also impaired after 24 h in the second challenge.

The percent of demand satisfied decreased with time in Teams 1,2 (second challenge), and 4. This occurred even though preplanned data were usually at the guns when a target was specified as priority by the role player. Specifically, for Teams 1, 2, 3, and 4 data were already at the guns 87, 94, 96, and 67% of the times when each sergeant failed to specify a target as priority. Although in these circumstances each sergeant only needed to announce the priority target number to the guns, all but one increasingly failed to do so. We suspect attention to detail and involvement increased markedly with time as teams attempted to keep current on their preplanning. Such demands made it more likely that responsible members did not hear the information when it came over the radio or they subsequently forgot it. Additional analyses will document why this critical performance was not maintained.

SYSTEM OUTPUT: UNPROCESSED PREPLANNED TARGET DEMANDS

The quantity of work never done may be more useful as an index of team capacity and performance efficiency than increased errors or latencies. Table I highlights differences between the 4 teams on preplanned target activities. Entries show the percentage of various preplanned target activities, as well as percentage of total target processing never completed. Several trends are evident. Total target processing was less adequate at 36 h for Teams 1 and 4 (Design I) than for Teams 2 and 3 (Design II); revising and updating contributed predominately to this trend. Although one cannot rule out level of training, experience, and organizational variables these data suggest the uncertainties, expectancies, and demands of an 86 h challenge took an earlier and greater toll on Teams 1 and 4. This observation is further supported by trends in the biochemical data (6). Secondly, Team 4, the least proficient and experienced team, was the team which demonstrated the least adequate total target processing. Lastly, updating was the preplanning target activity most frequently not completed by all four teams. It is interesting that updating was the only preplanned target activity done by a single team member.

Table I. Percentages of various uncompleted, preplanned target tasks. Values are shown for the 4 Teams studied for the initial 36 h in the simulation. Second challenge, 36 h comparisons are also shown for Teams 2 & 3. For Teams 1 & 4, 48 h comparisons are also indicated. Team 4's values for 45-48 h (interval after Team 4's termination) were extrapolated.

TEAM	PREPLANNING	PRIORITIZING	REVISING	UPDATING	% TOTAL TARGET PROCESSING NEVER COMPLETED
INITIAL 36 HOUR COMPARISON (CHALLENGE 1)					
1	4	8	4	100	29
2	2	5	0	12	5
3	9	10	0	36	14
4	9	27	28	86	38
SECOND 36 HOUR COMPARISON (CHALLENGE 2)					
2	2	11	0	11	6
3	12	7	0	10	10
INITIAL 48 HOUR COMPARISON					
1	11	14	14	95	34
4	19	34	49	88	48

INTERACTION ANALYSES

Figure 3 shows total CUs, i.e. all team members' CUs during the two lulls, each 6 h for Teams 1, 2, and 4. Task SOP and All Other CUs totals are also shown. Total communications declined with increasing h in all three teams. Maximal values ranged from 850-1200 CUs for the two 12 min lulls analyzed. Minimum values for each team were approximately 50% of maximum.

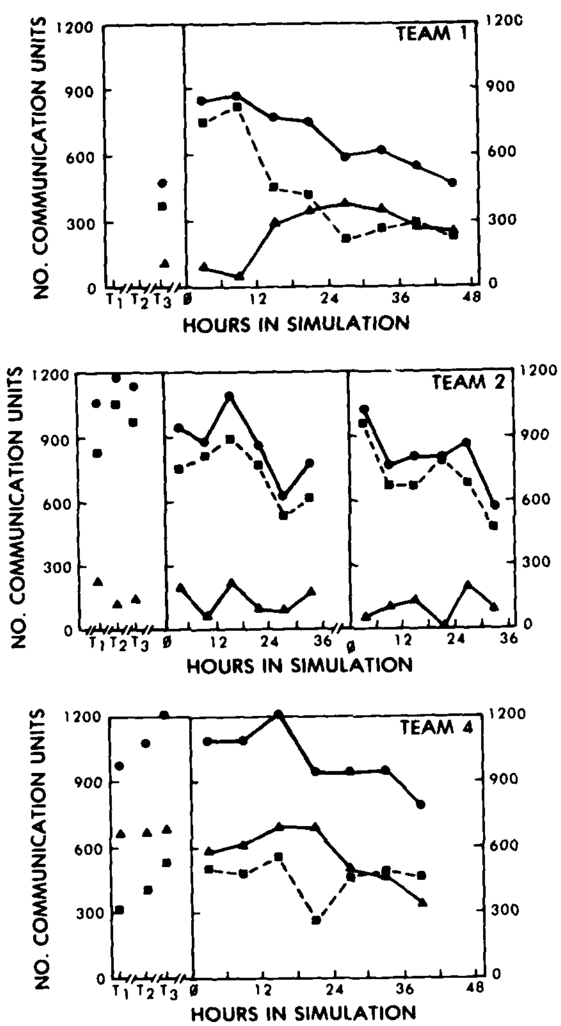


Figure 3. Group communication units (CU) for two, 12-min lulls are shown as a function of increased h in the simulation. Total CUs (solid circles), Task SOP CUs (solid squares), and All Other CUs (solid triangles) are shown.

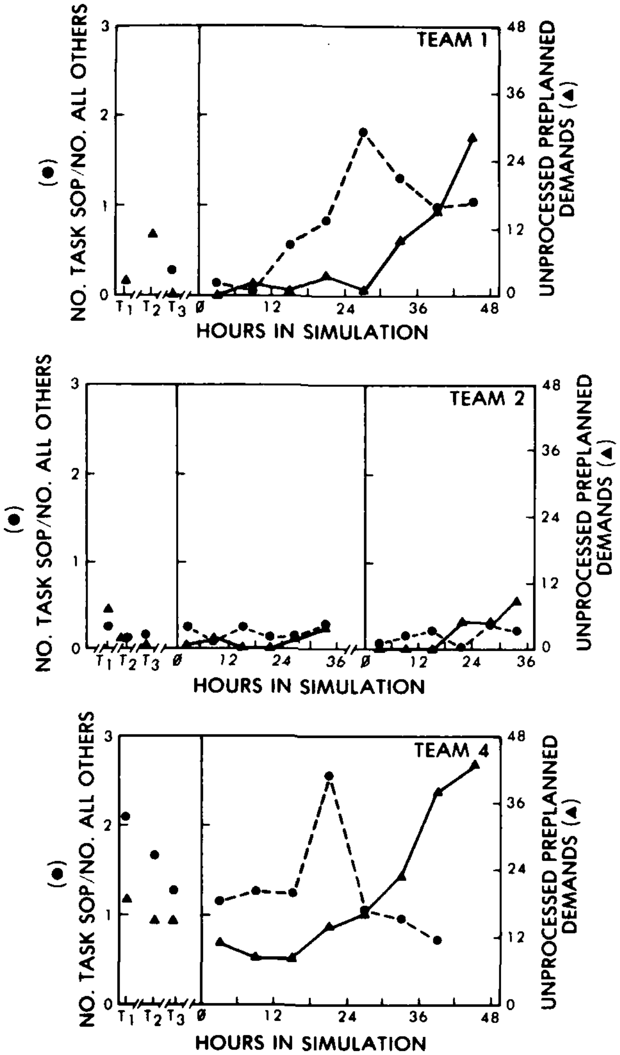


Figure 4. Task-related ratios (solid circles) and number of unprocessed preplanned demands (solid triangles) are shown for Teams 1,2 and 4 as a function of h in the simulation. Unprocessed preplanned demands are the sum of any revising, preplanning, and prioritizing targets which were not completed by each team. Increased task-related ratios indicate a greater preponderance of Task SOP CUs to All Other CUs.

Shown in Figure 4 are unprocessed preplanned demands and task-oriented ratio functions for each team with h in the simulation. The former measure is the total number of targets not completed from the preplanning, prioritizing, and revising tasks; the latter indicates the relative preponderance of Task SOP CUs to All Other CUs. Larger ratios generally occurred when a team had preplanning activities to perform during the lulls.

The teams differed markedly in how "lulls" were used. Teams 1 and 4 are similar but unlike Team 2. Team 2 used the lulls to rest and to interact with each other. In contrast, Teams 1 (after 12 h) and 4 engaged heavily in Task SOP CUs. This is shown dramatically by the fact that Team 2's ratios were typically $\leq$0.3; whereas, after 12 h, Team 1's ratios were always $\geq$1.0, except in the final hours prior to termination. In Teams 1 and 4, increased unprocessed demands were evident after 30 and 18 h; however, increases in the task-oriented ratio preceded these performance changes. With increasing unprocessed preplanned demands, communications became more task-oriented for Teams 1 and 4 up to some limit. Thereafter, the ratios decreased although both teams had increased amounts of unprocessed demands. Hence, after 24-30 h Task SOP CUs decreased in spite of increasing backlogs which eventually resulted in dramatic operational failures. The decreases in task-related communications reflected the fact that fewer and fewer task communications followed SOP and individuals began to discuss other topics. Although teams often remained concerned with task requirements, their behaviors became much less goal directed and their nonstandard communications reflected this. Such deviations sometimes resulted in confusion; increased effort and attention were required for task demands.

Team 2's data are in marked contrast to these data just described. At 36 h (second challenge) unprocessed demands were comparable to those for Team 1, yet changes in the task-oriented ratio were not observed. It was previously cited the single 86 h challenge took an earlier and greater toll on Teams 1 and 4 and that Team 2 was more proficient at preplanning. It appears that Team 2 had more reserve capacity and were able to maintain their preplanning without using the lulls. At no time was their ratio >0.3 Other interaction data for Team 2 (not shown) indicate that 18-30 h in the second challenge CU's showing negative affect (feelings) increased almost 200%, a level even greater than that observed after 36 h in the first challenge. Positive affect CU's dropped to an unprecedented low after 24 h. In fact, after appraising their multiple mission sequence performance at 27 h, Team 2 members expressed doubts to each other about their ability to finish the challenge. This was a remarkable display of self-and team-doubt since they completed the first challenge and knew the second was the same duration! These trends contrast with those from Team 2's first challenge and correlate nicely with the observed deteriorations in preplanning and prioritizing noted previously for Team 2.

Increased Task SOP CUs are a likely compensatory reaction to reduced individual and team efficiency and the recognition that more and more demands remain to be completed. In Teams 1 and 4, increased task-related ratios were evident 0-30 and 0-18 h, before unprocessed demands began to increment substantially. Later, when the compensation was no longer adequate to oppose the increasing amounts of unsatisfied demands, compensatory behavior was reduced. This occurred perhaps to conserve, knowing that only 24-30 h of the simulation were completed, or perhaps these demands have physiologic or neuroendocrine costs which cannot be ignored and must be repaid. Biochemical and physical fitness data for Teams 1 and 2 (6) documented different patterns of response for each team; analogous data were not collected for Team 4.

These interaction data suggest that teams and their predominant activities can be characterized by communications occurring during lull periods. Furthermore, number and type of communications bear some relationship to operational and performance capabilities at that time. In the future, the contributions of various individuals to each group's communications will be explored. Ultimately, other biomedical indices will be arrayed with the operational performance data to gain insights as to how selected physiological, biochemical, and social variables influence operational capabilitites in small Army teams.

CONCLUSIONS

1. Teams 1 and 4 ended their participation in the simulation at times corresponding to their physiological lows. Instruction, experience, leadership and social support can attenuate the impact of these physiological effects.
2. The 86 h single sustained operations challenge (Design I) was more demanding at equivalent points in time than the two, 38 h repeated challenges separated by 34 h of rest (Design II). Performance deteriorations occurred earlier and were greater. The implied mission demands, self- and team-doubts, and uncertainties associated with the anticipated 86 h challenge were likely contributing factors.
3. Performance deterioration appeared in most teams after 30-36 h in the simulation. Adverse environments, real-world situational uncertainties, and combat conditions would likely have additional disruptive influences.
4. Analyses of communications during lulls appear to provide useful correlates (predictors) of changes in team performance. Compensation and conservation reactions were also inferred.
5. This project methodology is adaptable to field research and training situations. The program suggests training, supervision, task, and biomedical issues for reducing the impact of sustained operations upon military personnel.

REFERENCES

1. Johnson, L. C., and P. Naitoh. 1974. The operational consequences of sleep deprivation and sleep deficit. AGARD-AG-193.
2. Woodward, D. P. and P. A. Nelson. 1974. A user- oriented review of the literature on the effects of sleep loss, work-rest schedules, and recovery on performance. Office of Naval Research, ACR.
3. Davis, R. H., and Behan, R. A. 1962. Evaluating system performance in simulated environments. In R. M. Gagne (Ed), Psychological Principles in System Development. Holt, Rinehart, & Winston, New York, 476-515.

(208)

4. Glanzer, M. Experimental study of team training and team functioning. In R. Glaser (Ed), Training Research and Education. J. Wiley & Sons, New York, 379-407.
5. Bourne, P. G. The Psychology and Physiology of Stress (Vietnam). Academic Press, New York.
6. Banderet, L. E., J. W. Stokes, R. Francesconi, D. M. Kowal, and P. Naitoh, 1981. Artillery Teams in Simulated, Sustained Combat: Performance and Other Measures. In L. C. Johnson, D. I. Tepas, W. P. Colquhoun, & M. J. Colligan (Eds.). The 24-Hour Workday. A Symposium on Variations in Work-Sleep Schedules. National Institute for Occupational Safety and Health, Washington, D.C., (in press).
7. Stokes, J. W., L. E. Banderet, R. P. Francesconi, A. Cymerman, and J. B. Sampson. 1975. The Field Artillery Fire Direction Center as a laboratory and field stress-performance model: I Position paper; II Progress towards an experimental model. In The Role of The Clinical Laboratory in Aerospace Medicine, AGARD Publication AGARD-CP-180, A10-1 to A10-10.
8. Bales, R. F. 1970. Personality and Interpersonal Behavior. Holt, Rinehart & Winston, Inc, New York.
9. Stokes, J. W., and L. E. Banderet. 1978. A War for Science. Field Artillery Journal, 43-44.

ADDENDA

Human subjects participated in the studies after giving their free and informed voluntary consent. Investigators adhered to AR 70-25 and USAMRDC Regulation 70-25 on Use of Volunteers in Research.

The views, opinions, and/or findings contained in this report are those of the author(s) & should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other official documentation.

The studies reported were conducted jointly by USARIEM, the Walter Reed Army Institute of Research (WRAIR), and the Naval Health Research Center (NHRC) in 1977. The administrative, technical, and professional contributions of numerous individuals are acknowledged and greatly appreciated.