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The Effect of Pain on Task Performance
A Review of the Literature

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13. ABSTRACT *(Maximum 200 words)*

The authors reviewed 273 abstracts relating to pain and 36 abstracts relating to pain and task performance. Of the 309 abstracts reviewed, 93 articles were pertinent to elements of the problem and are the basis of this report; however none specifically related burn pain to task performance.

Two simple five-point scales were found that can be used to measure pain severity resulting from burns. The first is the McGill Pain Questionnaire that has been widely used, and the second is the Visual Analogue Scale which is often used together with a Verbal Rating Scale developed by Banos. Some alternatives to a five-point scale to relate pain severity to performance are presented as offering potential for further development.

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PREFACE

Technico Southwest Incorporated (TSI) is conducting a study of the effects of combined injuries under contract DNA-001-88-C-0207. The Human Response Program of the DNA has convened a combined injury working group of renowned experts in radiation, thermal and blast injuries. This working group is extending and building on the results of the DNA Intermediate Dose Panel (IDP) which limited itself to performance degradation from exposure to ionizing radiation.

Preliminary evaluation of the symptom of thermal injury by a number of burn surgeons showed that many of the systemic symptoms associated with burns are also associated with exposure to ionizing radiation. A notable exception was the pain associated with burns.

The effect of the systemic symptoms on performance was studied in great detail by the IDP, but the effect of pain was not. In order to evaluate the impact that pain might have on performance, a review of the literature was requested of TSI by the combined injury working group. TSI was fortunate in being able to obtain the services of two prominent psychologists, Drs. Gamache and Glickman. These psychologists had participated in the development of the methodology of the IDP and were thus familiar with the requirements, methods and symptomology associated with that study.

The present study is the result of their intensive efforts at providing the information requested by the combined injury working group.

CONVERSION TABLE

Conversion factors for U.S. Customary to metric (SI) units of measurement.

MULTIPLY ⟶ BY ⟶ TO GET
TO GET ⟵ BY ⟵ DIVIDE

angstrom	1.000 000 X E -10	meters (m)
atmosphere (normal)	1.013 25 X E +2	kilo pascal (kPa)
bar	1.000 000 X E +2	kilo pascal (kPa)
barn	1.000 000 X E -28	meter^2 (m^2)
British thermal unit (thermochemical)	1.054 350 X E +3	joule (J)
calorie (thermochemical)	4.184 000	joule (J)
cal (thermochemical)/cm^2	4.184 000 X E -2	mega joule/m^2 (MJ/m^2)
curie	3.700 000 X E +1	giga becquerel (GBq)*
degree (angle)	1.745 329 X E -2	radian (rad)
degree Fahrenheit	$t_K = (t°f + 459.67)/1.8$	degree kelvin (K)
electron volt	1.602 19 X E -19	joule (J)
erg	1.000 000 X E -7	joule (J)
erg/second	1.000 000 X E -7	watt (W)
foot	3.048 000 X E -1	meter (m)
foot-pound-force	1.355 818	joule (J)
gallon (U.S. liquid)	3.785 412 X E -3	meter^3 (m^3)
inch	2.540 000 X E -2	meter (m)
jerk	1.000 000 X E +9	joule (J)
joule/kilogram (J/kg) (radiation dose absorbed)	1.000 000	Gray (Gy)**
kilotons	4.183	terajoules
kip (1000 lbf)	4.448 222 X E +3	newton (N)
kip/inch^2 (ksi)	6.894 757 X E +3	kilo pascal (kPa)
ktap	1.000 000 X E +2	newton-second/m^2 (N-s/m^2)
micron	1.000 000 X E -6	meter (m)
mil	2.540 000 X E -5	meter (m)
mile (international)	1.609 344 X E +3	meter (m)
ounce	2.834 952 X E -2	kilogram (kg)
pound-force (lbf avoirdupois)	4.448 222	newton (N)
pound-force inch	1.129 848 X E -1	newton-meter (N·m)
pound-force/inch	1.751 268 X E +2	newton/meter (N/m)
pound-force/foot^2	4.788 026 X E -2	kilo pascal (kPa)
pound-force/inch^2 (psi)	6.894 757	kilo pascal (kPa)
pound-mass (lbm avoirdupois)	4.535 924 X E -1	kilogram (kg)
pound-mass-foot^2 (moment of inertia)	4.214 011 X E -2	kilogram-meter^2 (kg·m^2)
pound-mass/foot^3	1.601 846 X E +1	kilogram/meter^3 (kg/m^3)
rad (radiation dose absorbed)	1.000 000 X E -2	Gray (Gy)**
roentgen	2.579 760 X E -4	coulomb/kilogram (C/kg)
shake	1.000 000 X E -8	second (s)
slug	1.459 390 X E +1	kilogram (kg)
torr (mm Hg, 0°C)	1.333 22 X E -1	kilo pascal (kPa)

* The becquerel (Bq) is the SI unit of radioactivity; 1 Bq = 1 event/s.
**The Gray (Gy) is the SI unit of absorbed radiation.

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SECTION 1
INTRODUCTION

A study of the effects of pain on task performance was requested by TSI. In particular the authors were asked 1)to provide recommendations for a five-point pain severity scale appropriate for pain resulting from burns and 2)to locate and recommend a model to predict the effect of pain on the performed of cognitive and/or of physically demanding military type tasks. If no prediction model could be found, recommendations for an approach to the development of such a model were elicited.

In response to that request, a bibliography of the scientific literature was analyzed. The authors reviewed 273 abstracts that were assessments of pain alone and 36 abstracts that related pain to task performance. Based on these abstracts, 91 articles were selected as pertinent to the task and were reviewed in detail. These reports and the personal experience of the authors form the basis of this report.

SECTION 2
PAIN SCALES

Pain is one of the most difficult of the clinical symptoms to evaluate. It is a very complex phenomenon and not always associated with injury. Moreover, the experience of pain does not consistently result in degradation in performance. Examples abound in the military reports where personnel while experiencing excruciating pain have still completed their assigned mission. Discipline and motivation can assist personnel in overcoming pain to complete a battlefield mission. A finger crushed while chopping fire wood at home would send a soldier to the hospital, whereas, medical attention might not be sought by the same soldier on the battlefield. Battlefield mission imperatives may preclude immediate medical attention for any but life threatening wounds.

The relationships among injury, pain, and performance degradation may vary at different times and under different conditions. The correlation could be linear, curvilinear, or cyclical and could be modified by physiological, psychological, chemical, and/or neurological processes. To a significant extent, pain is a personal experience that defies completely objective measurement. Because a significant part of the pain experience is subjective, it is very difficult to specify its intensity and quality (Ref. 10). Such psychological factors as mood and cognition as well as behavioral components contribute to the individual's perception and response to pain; pain theorists have stressed that somatic and psychological factors interact in the experience and both must be considered in estimating its effect.

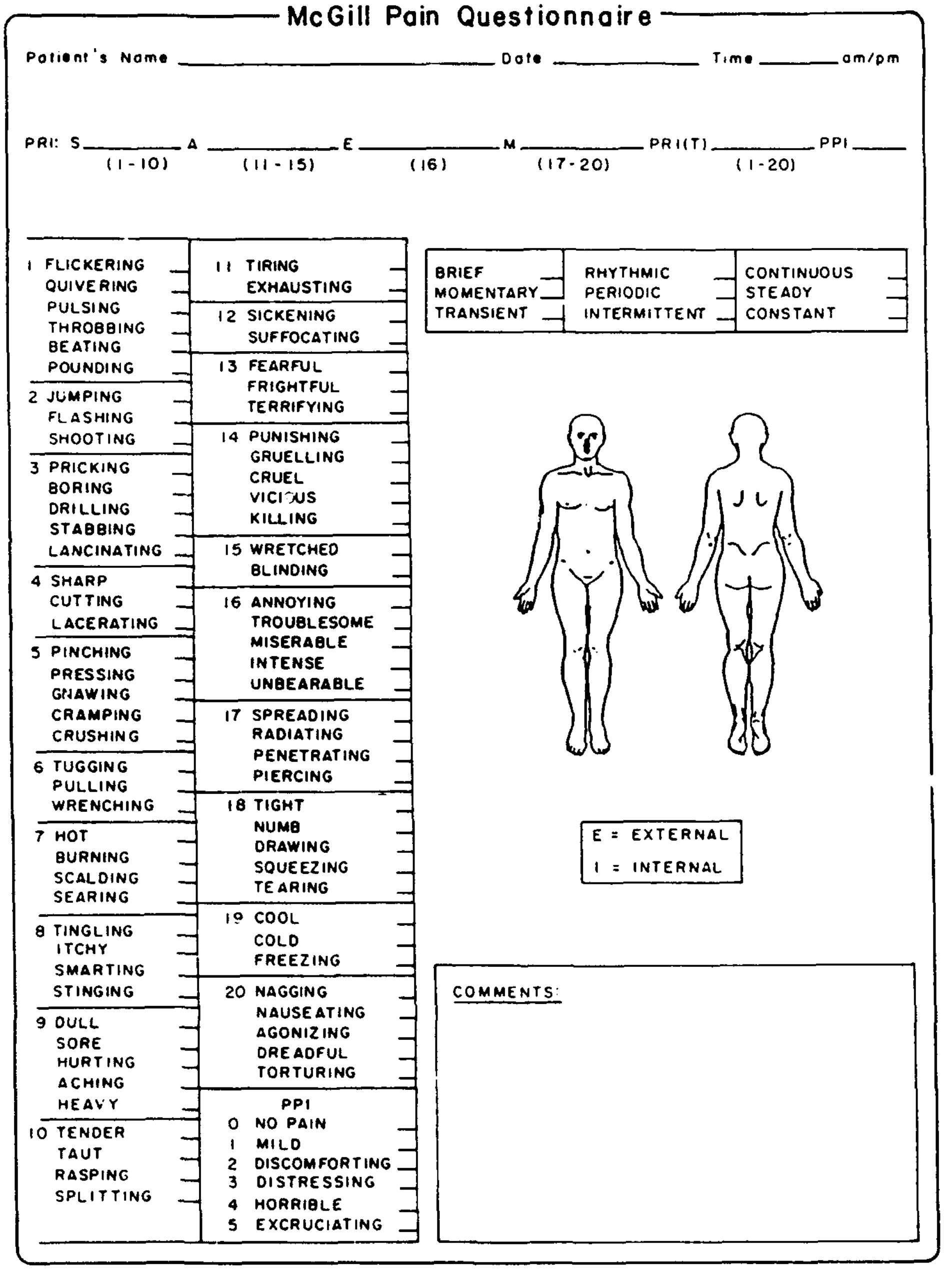
2.1 MCGILL PAIN QUESTIONNAIRE.

The McGill Pain Questionnaire (MPQ), originally called "the Melzack-Torgerson Questionnaire" after an article by them in 1971 (Ref. 56), has been used both in clinical trials and in research to elicit the quality and severity of pain experienced. By 1975, the name had been changed to MPQ (Ref. 55).

At least five versions of the MPQ have been identified in the literature (Ref. 53, 55, 57). With the exception of the short-form version, all versions of the MPQ include a body outline drawing which is used to specify the location of the pain. Also common to all versions of the MPQ is a five-point scale of pain descriptors to indicate the Present Pain Intensity (PPI). The MPQ consists of two parts. In the first part word descriptors in four major dimensions--sensory, affective, evaluative and miscellaneous--are used by patients to specify the pain they experience. With the exception of the miscellaneous group all dimensions were theoretically derived (Ref. 56).

Figure 1 presents the MPQ published version. Location of pain is marked as external (E) or internal (I) on the body sketches. The sensory dimension includes 42 words clustered into groups 1 through 10. Each group contains three to six words. Words with a similar sensory quality of pain are grouped together. These qualities include punctate pressure, constrictive pressure and incisive pressure. The affective dimension includes 14 words divided into five groups (11-15) with two to five words per group. Affective words represent tension, fear, punishment, and autonomic aspects of pain. Five words are included in the one group (16) that represents an evaluative dimension of pain. Fourteen words are included in four groups (17-20) that represent miscellaneous qualities of pain. Nine terms are used to describe time patterns.

Three types of scores are commonly elicited by the MPQ. First, the Pain Rating Index (PRI) is based on the rank values of the descriptors selected; each descriptor is ranked in its group; the descriptor implying the least pain in its group is given a value of 1, the next word is given a value of 2, etc., and the values of words chosen are then added up to obtain a score for each dimension. Dimension scores are added to give a grand total. The second score is a count of descriptors chosen. The third score, the Present Pain Intensity (PPI), is a separate 1 to 5 scale used to determine pain intensity at the time of reporting: 1 = mild, 2 = discomforting, 3 = distressing, 4 = horrible, and 5 = excruciating.



McGill Pain Questionnaire

Patient's Name ____________ Date ________ Time ______ am/pm

PRI: S ______ (1-10) A ______ (11-15) E ______ (16) M ______ (17-20) PRI(T) ______ (1-20) PPI ______

1 FLICKERING QUIVERING PULSING THROBBING BEATING POUNDING	11 TIRING EXHAUSTING
2 JUMPING FLASHING SHOOTING	12 SICKENING SUFFOCATING
3 PRICKING BORING DRILLING STABBING LANCINATING	13 FEARFUL FRIGHTFUL TERRIFYING
4 SHARP CUTTING LACERATING	14 PUNISHING GRUELLING CRUEL VICIOUS KILLING
5 PINCHING PRESSING GNAWING CRAMPING CRUSHING	15 WRETCHED BLINDING
6 TUGGING PULLING WRENCHING	16 ANNOYING TROUBLESOME MISERABLE INTENSE UNBEARABLE
7 HOT BURNING SCALDING SEARING	17 SPREADING RADIATING PENETRATING PIERCING
8 TINGLING ITCHY SMARTING STINGING	18 TIGHT NUMB DRAWING SQUEEZING TEARING
9 DULL SORE HURTING ACHING HEAVY	19 COOL COLD FREEZING
10 TENDER TAUT RASPING SPLITTING	20 NAGGING NAUSEATING AGONIZING DREADFUL TORTURING
	PPI 0 NO PAIN 1 MILD 2 DISCOMFORTING 3 DISTRESSING 4 HORRIBLE 5 EXCRUCIATING

BRIEF MOMENTARY TRANSIENT	RHYTHMIC PERIODIC INTERMITTENT	CONTINUOUS STEADY CONSTANT

E = EXTERNAL
I = INTERNAL

COMMENTS:

Figure 1. The McGill pain questionnaire.

The pain quality descriptors have changed very little since the creation of the first version of the MPQ. One might wonder whether words such as "discomforting", "distressing" and "excruciating" are meaningful to physicians but not to a considerable number of their patients.

Considerable documentation is available to support the reliability of the MPQ as a measure of pain quality and pain intensity (Ref. 20, 63, 67, 83). Reliability testing procedures have involved physicians, university graduate students, and patients who were asked to classify 146 words into small groups describing distinctly different qualities of pain. On the basis of the data, the words were classified into three major dimensions (sensory, affective, and evaluative) and sixteen subclasses (temporal, spatial, punctate pressure, incisive pressure, constrictive pressure, tractive pressure, thermal, brightness, dullness, sensory miscellaneous, tension, autonomic, fear, punishment, affective miscellaneous, and anchor words); then numerical values were assigned each word by the group. Turk, Rudy, & Salovey (Ref. 86) found some of the MPQ scores highly intercorrelated. Possibly, therefore, valid multidimensional measures are obtained. Alternate forms reliability ($r = .83$) (Ref. 64), test-retest reliability ($r = .91$) (Ref. 55) and sensitivity to standardized stimuli ($r = .35 - .90$) (Ref. 42) have been documented. The only part of the MPQ that is scaled, the Present Pain Intensity (PPI), which measures pain intensity at the time the test is administered, is a self-report scale. Blasco and Bayes (Ref. 9) regard self-report scales and demand characteristics as potentially unreliable; the reaction of an individual varies if the instructions are "high-demand" or "low-demand."

No manual of test administration is known to be available. Rather Melzack's 1975 article (Ref. 55) is distributed, and administration instructions must be derived from the brief discussion of procedures when the MPQ is used. Two different versions were presented in that publication. The two versions bear identical names but differ in several important ways, such as length of the instrument, number of symptoms assessed, and number of response options for the pain pattern and pain intensity items. These differences complicate comparisons of studies based on that reference. Furthermore, data are lacking regarding normative scores, especially for populations with different pain syndromes; for example, dental pain, post-operative pain and GYN pain. Normative scores are based upon large samples and are intended to be representative scores for the population. Since seven scores are derived from the MPQ (five dimensions + word score + PPI score) such normative data are important, so that researchers and practioners may interpret their finding when they use the MPQ on different categories of people.

The concept of pain dimensions, extent and severity does serve clinical needs but does not relate the pain to degradation in performance. Pain implies disability or degradation in performance. One cannot experience appreciable pain and not be in some way disabled by it. While a number of studies have examined variables such as pain intensity and duration (Ref. 27,62, 91), little attention has been paid to the disability associated with chronic or enduring pain. Disability is conceptually distinct from the concept of impairment, which refers specifically to a limitation of some bodily function for which there is an objective physiological cause. By contrast, Pollard (Ref. 61) defined pain disability as "the extent to which chronic pain interferes with a person's ability to change in various life activities." The degree, extent, or duration of impairment(s) will determine the degree, extent, or duration an individual will be unable to adequately perform certain normal life functions, i.e., family/home responsibilities, recreation, social activities, occupation, sexual behavior and self care. The degradation due to disability depends on the complex interplay among variables such as intensity, extent, and duration, and other factors that are not aspects of pain itself, including emotional and cognitive responses, environmental contingencies, and job demands.

2.2 OTHER SCALING TECHNIQUES.

A number of other pain scaling techniques have been described. Foremost among these is the Visual Analogue Scale (VAS) (Ref. 38). A 10-cm line is the basis of the VAS. "No pain" anchors one end, and "severe pain" anchors the other end. The orientation of the line can be horizontal or vertical. There have been several modifications of the VAS (Ref. 7, 79) as well as other attempts at scaling pain intensity (Ref. 10, 74). Brattberg et al. (Ref. 10) attack the vagueness of the VAS and propose a five-point scale based on its effect on behavior (1 = no pain, 2 = pain present, but cannot easily be ignored, 3 = pain present, cannot be ignored, but does not interfere with everyday activities, 4 = pain present, cannot be ignored, interferes with all tasks except basic needs such as using the toilet and eating, 5 = pain present, cannot be ignored, rest or bedrest required). The advantage of this approach is that it creates an observable, behaviorally anchored scale related to the subject's actual performance. For example, if number 4 is chosen (pain present, cannot be ignored, interferes with all tasks except basic needs such as using the toilet and eating), the descriptor is observable and reflects actual performance.

Finally, Banos, et. al. (Ref. 7) use a Verbal Rating Scale (VRS) in conjunction with the VAS with significant correlational results (p = .001) between the two scales. The VRS scaling is 0 = no pain, 1 = mild pain, 2 = severe pain, 3 = very severe pain, 4 = unbearable pain. When VRS values were compared with results obtained by VAS, no pain (VRS = 15.5%) appeared to be equivalent to the VAS 0-0.2 interval (VAS = 16.4%), mild pain (VRS = 58.6%) to the VAS 0.3-4 interval (VAS = 61%), severe pain (VRS = 19%) to the VAS 4.1-6 interval (VAS = 13.2%) very severe pain (VRS = 4%) to the VAS 6.1-8 interval (VAS = 5.1%) and unbearable pain (VRS = 2.9%) to the highest VAS values 8.1-10 (VAS = 3.1%).

These last two scales come closest to providing a simple usable five point scale that can be applied to pain of thermal injury.

SECTION 3
EFFECT OF PAIN ON TASK PERFORMANCE

We reviewed 36 articles related to pain and task performance. The most promising of these came from the National Institute of Occupational Safety and Health (NIOSH) database relating to pain experienced by subjects engaged in manual lifting (Ref. 4, 8, 16, 52, 65, 75, 81). The subjects were in pain, and its effect on lifting, walking and bending-over was measured although the pain was not scaled. Caldwell & Smith (Ref. 11) measured constant pressure on a hand dynamometer under conditions of normal and restrictive blood flow. Teichner & Kobrick (Ref. 82) measured decrements in performance on visual-motor (pursuit rotor) and flicker fusion (glow modulator tube) tasks while the subject was exposed to low temperature. Three articles involved the Cold Pressor Test (Ref. 9, 21, 87). The Cold Pressor Test uses two tanks of water: one contains warm water at (32 deg C) and the other very cold water (0 deg C). The subject is instructed to immerse his nondominant hand up to the wrist, first in warm water - for 1 minute - and then immediately in the cold water. The subject is instructed to say "Now" when first experiencing a pain sensation and to leave the hand in the water up to 5 minutes to provide a measure of tolerance. In their use of the cold pressor test, Walsh et al. (Ref 87) used demographic data and Efran et al. (Ref. 21) used personality constructs to predict pain duration. Blasco et al. (Ref. 9) discussed the unreliability of the Cold Pressor Test method in pain studies.

Szekely, et al. (Ref 77) used injections of pro^5-enkephalinamide (EA) and the subsequent application of a tourniquet (the cuff of a conventional blood pressure apparatus) to produce pain and measured performance degradation. Their measure of performance included the symbol cancellation test developed by Le Toulouse et al. (Ref. 48), Wechsler Adult Intelligence Scale (WAIS) (Ref. 88), and the Word Fluency Test developed by Guilford (Ref. 34). This research was conducted in Hungary. Replication might not be acceptable with human subjects in this country.

Dr. Joshua Vayer, Research Assistant Professor, Department of Military Medicine, Uniformed Services University of the Health Sciences, has assembled a massive database on combat injuries particularly those injuries sustained in Viet Nam. He confirmed the absence of any research relating pain to task performance, and referred to the Sperrazza and Blair (Ref. 69) research on pain related to artillery and howitzer wounds suffered in Viet Nam. The basis for the study was 500 autopsies; the severity of pain was conjectured based on the physical location of the wound.

SECTION 4
CONCLUSIONS

We found no studies that directly related burn pain to task performance in any government report or the database of scientific journals. Furthermore we found no studies relating scaled pain to measured degradation in performance. New research studies would be required to develop such information and suggestions will be made in the section of recommendations which follows.

Pain itself is a very complex phenomenon that involves physiological, psychological, and environmental factors. It's measurement is elusive. The measurement of pain must be associated with behavioral anchors if it is to be meaningful. Glickman, Winne, Morgan & Moe (Ref. 29) have provided a model that could be adapted to relate behaviorally anchored pain scales to measured decrements in performance. Their study is the most fully developed prototype of an approach relating symptoms to performance. It was conducted as part of the earlier contract generated by the Defense Nuclear Agency Intermediate Dose Panel (IDP).

Only two of the scales, Banos et al. (Ref. 7) and Brattberg et al. (Ref. 10), appear to warrant further research. If a five-point rating scale must be used in such studies, we would recommend using the Brattberg scale since it represents a behaviorally anchored scale. These two represent the best of the five-point scale studies for the purposes stated as none of the other literature reviewed was applicable. Both the MPQ and VAS are inadequate as scaling techniques: in the MPQ you pick the word that best describes what you are feeling and its use is primarily restricted to patients who are currently experiencing pain; the VAS does not provide scaling between anchors since only the extremes are scaled (0 = no pain, 10 = severe pain). Both of these instruments are most appropriate for a clinical setting rather than in empirical research dealing with situations involving subjective judgments on how much pain would be associated with a given symptom set and the consequence for task performance. The essential difference is between actual real time experiences versus subjective experiences that are reconstructed retrospectively.

SECTION 5
RECOMMENDATIONS

The approaches described in this section analyze pain as a constituent of symptom complexes and propose ways to estimate degradation of performance.

5.1 SYMPTOM COMPLEX APPROACH.

The Glickman et al. (Ref. 29) prototype can be used as the framework of an approach to study the effects of pain upon performance in which pain is one element of a larger symptom complex. That prototype study was conducted to investigate the effects of intermediate doses of radiation from nuclear weapons on the performance of military and non-military tasks. Participants were operational Army personnel who were asked to estimate the effects of 40 sets of symptoms on a variety of military tasks (e.g., artillery firing, fire direction, tank driving), as well as on ordinary non-military tasks (e.g., climbing, lifting). The symptoms represented a range of low to high severity radiation effects (see Appendix A). The effect of each symptom set was assessed in terms of (1) the percent of respondents who judged that the performance would be unaffected, (2) the percent who judged that incapacitation would result, and (3) the average expected degradation, expressed as a percent of normal performance. In addition, multiple regression analyses were used to assess the relative importance of six components of the symptom complexes in determining the expected degree of impairment.

The suggestion here is to extend the methodology outlined by adding pain to the symptom sets while remaining within the context of radiation sickness. Of course, essentially the same methodology could be applied to illness and injury induced by other means (e.g., burns).

The Verbal Rating Scale (VRS) (Ref. 7) might be used to measure pain in conjunction with the Glickman et al. (Ref. 29) symptom complexes. Key words such as: vomited (as opposed to nauseated which does not imply pain), upset stomach, headache, dry heaves, the uncomfortable urge to defecate, and sores in the mouth and throat could be used. We have identified 25 symptom complexes that are potentially pain producing (those marked * in the Appendix). The degradation due to these symptoms has been estimated (Ref. 29).

There are two steps that would be involved in scaling the pain. First, an Army noncommissioned officers (NCO) sample would be chosen as in the Glickman et al. study, or perhaps medical personnel, to verify which of these 40 symptom complexes are indeed pain producing. The second step would be to have the Army sample designate "Pain associated with the above symptoms" using the scale in accordance with the Banos et al. (Ref. 7) approach.

5.2 CRITICAL INCIDENTS APPROACH.

Rating scales might not be the appropriate measurement tool to adequately answer the question of how injury is related to pain and, further, how it is related to task performance degradation. We believe that the central requirement is to build indices of relationship between pain and behavior/performance in some meaningful paradigm. The use of rating scales provides one dimension of measurement. Pain, as we have seen, is a multidimensional phenomenon to which you would have to apply multidimensional measurements. Utilization of the critical incident approach (Ref. 23, 24, 25, 28) offers promise as an alternative multidimensional approach. Critical incidents are actual, observed examples of behavior that appear critical in determining whether associated outcomes represent effective or ineffective performance. In the case of pain, subjects might be asked to cite examples of situations in which pain was experienced during work and performance was affected. Thus, one could ask subjects to "think of an occasion when you experienced the most intense pain in your life" accompanied by other questions for describing what happened, symptoms, how the ongoing task was affected, and so forth. Some questions one might ask: What was the most recent incident when you experienced an uncomfortable amount of pain? What did you do about it? What were you working at? Did you stop? Did you not do something that you were going to do before you felt the pain? How long did you postpone or interrupt what you would otherwise have been doing? One could then add questions about pressures to continue work or task activities. Answers to these questions could be analyzed to provide data regarding the relationship of pain to subsequent behavior, and ultimately, to task performance. Utilizing critical incident techniques has been shown to be an efficient way of collecting a large diverse body of behavioral data and arriving at a series of reliable, meaningful conclusions regarding relationships that exist among factors and their effect on task performance.

5.3 MEASUREMENT OF PERFORMANCE APPROACH.

The Cold Pressor Test could be combined with psychological measurements of performance (Ref. 34, 48, 88) to relate scaled pain to measured decrements in performance in the laboratory setting. Behavioral and psychological tasks which approximate critical incidents involved in soldiering skills in the battlefield, such as taking an azimuth or simulating the pulling of a lanyard to fire artillery, could be used. The Arithmetic, Digit Span, and Picture Completion subtests on the WAIS (Ref. 88) are examples of types of tasks that might be candidates for approximating effects on critical incidents, of pain on cognitive functions such as mathematics and problem-solving. A host of simulations could be constructed to approximate a great variety of behavioral tasks. Through factor analysis one could group similar tasks, such as those involving computing skills, communication skills, or psychomotor performance skills. Then one could construct tests for each factor representative of the variables contained within that task. Since these tests are approximations of decrements in performance, not actual decrements in performance, the researcher would need two or more groups of subjects. One group would be tested under the "no pain condition" for the baseline of performance. The other groups would be tested under one or more "pain condition" for determining decrements in performance.

Three approaches to the development of a method to predict the effect of pain on performance have been proposed because an appropriate method does not exist in government reports or in the scientific journals. Development of an appropriate prediction model would require the collaboration of experts in: the effect of burns on pain, the performance of military tasks; and the construction of test instruments and measurement scales. The approaches that have been outlined are based on the existing pain scaling methods and build on the Glickman et al. (Ref. 29) prototype that used complexes of symptoms to estimate performance.

SECTION 6
LIST OF REFERENCES

1. M. D. Ackerman and M. J. Stevens, Acute and chronic pain: Pain dimen sions and psychological status. Journal of Clinical Psychology. 45 (2), 223-228 (1989)

2. J. Adams, Pediatric pain assessment: Trends and research directions. Journal Pediatric Oncology in Nursing. 6 (3), 79-85 (1989)

3. B. G. Almay, Clinical characteristics of patients with idiopathic pain syndromes. Depressive symptomatology and patient pain drawings. Pain. 29 (3), 335-346 (1987)

4. J. A. D. Anderson, Shoulder pain and tension in the neck and their relation to work. Scandinavian Journal of Work, Environment and Health. 10 (6), 435-442 (1984)

5. K. O. Anderson, et al., The assessment of pain in rheumatoid arthritis: Disease differentiation and temporal stability of a behavioral observa tion method. Journal of Rheumatology. 14 (4), 700-704 (1987)

6. E. M. Badley and A. C. Papageorgiou, Visual analogue scales as a measure of pain in arthritis: A study of overall pain and pain in individual joints at rest and on movement. Journal of Rheumatology 16 (1), 102-105 (1989)

7. J. E. Banos et al., Acceptability of visual analogue scales in the clinical setting: A comparison with verbal rating scales in postoperative pain. Methods and Findings Experimental Clinical Pharmacology. 11 (2), 123-127 (1989)

8. J. D. Benson, Application of manual handling task in the control of low back pain. In Trends in Ergonomics/Human Factors IV. Proceedings of the Annual International Industrial Ergonomics and Safety Conference. Amsterdam: Elsevier Science Publishers (1987).

9. T. Blasco and R. Bayes, Unreliability of the cold pressor test method in pain studies. Methods and Findings Experimental Clinical Pharmacology. 10 (12), 767-772 (1988)

10. G. Brattberg, et al., The use of common pain experiences in designing a pain intensity scale for epidemiological purposes. Journal of Psychoso matic Research. 32 (4-5), 505-512 (1988)

11. L. S. Caldwell and R. P. Smith, Pain endurance of isometric muscle contractions. Journal of Engineering Psychology. 5 (1), 25-32 (1966)

12. L. S. Caldwell et al., A comparison of two methods of scaling pain. (Report No. 797). Fort Knox, Kentucky: U. S. Army Medical Research Laboratory (1968)

13. L. F. Callahan et al., Quantitative pain assessment for routine care of rheumatoid arthritis patients, using a pain scale based on activities of daily living and a visual analogue pain scale. Arthritis and Rheumatism. 30 (6), 630-636 (1987)

14. W. C. Clark et al., The dimensions of pain: A multidimensional scaling comparison of cancer patients and healthy volunteers. Pain. 37 (1), 23-32 (1989)

15. M. M. Cohen and R. B. Tate, Using the McGill Pain Questionnaire to study common postoperative complications. Pain. 39 (3), 275-279 (1989)

16. B. G. Coury and C. G. Drury, Optimum handle position in a box-holding task. Ergonomics. 25 (7), 645-662 (1982)

17. G. C Davis, Measurement of the chronic pain experience: Development of an instrument. Research in Nursing Health. 12 (4), 221-227 (1989)

18. M. Deschamps et al., Assessment of adult cancer pain: Shortcoming of current methods. Pain. 32 (2), 133-139 (1988)

19. M. Donovan et al., Incidence and characteristics of pain in a sample of medical-surgical inpatients. Pain. 30 (1), 69-78 (1987)

20. D. Dubuisson and R. Melzack, Classification of clinical pain descriptors by multiple group discriminant analysis. Experimental Neurology. 51, 480-487 (1976)

21. J. S. Efran et al., Coping styles paradox and the cold pressor task. Journal of Behavioral Medicine. 12 (1), 91-103 (1989)

22. P. E. Finn, Chronic pain rehabilitation: A challenge for mental health counselors. Journal of Mental Health Counseling. 10 (2), 111-122 (1988)

23. P. M. Fitts and R. E. Jones, Analysis of factors contributing to 460 "pilot-error" experiences in operating aircraft controls. USAF Materiel Command Memo, Report TSEAA, 694-12 (1947a)

24. P. M. Fitts and R. E. Jones, Psychological aspects of instrument displays. I: Analysis of 270 "pilot-error" experiences in reading and interpreting aircraft instruments. USAF Materiel Command Memo, Report TSEAA, 694-12A (1947b)

25. J. C. Flanagan, The critical incident technique. Psychological Bulletin. 51, 327-358 (1954)

26. R.H. Fox, Local cooling in man. British Medical Bulletin. 17 (1), 14-18 (1961)

27. L. W. Frederiksen et al., Methodology in measurement of pain. Behavioral Therapy. 9, 486-488 (1978)

28. E. E. Ghiselli and C. W. Brown, Personnel and industrial psychology. New York: McGraw Hill (1955)

29. A. Glickman et al., Estimated Effects of Intermediate Levels of Nuclear Radiation upon the Performance of Military Tasks: A Questionnaire As sessment (DNA Report No. DNA-TR-85-51). Washington, D.C.: Defense Nuclear Agency. (DTIC No. DNA 001-83-C-0015) (1984)

30. R. H. Gracely and R. Dubner, Reliability and validity of verbal de scriptor scales of painfulness. Pain. 29 (2), 175-185 (1987)

31. R. H. Gracely and D. M. Kilosz, The descriptor differential scale: Applying psychophysical principles to clinical pain assessment. Pain. 35 (3), 279-288 (1988)

32. R. H. Gracely et al., A multiple random staircase method of psychophysi cal pain assessment. Pain. 32 (1), 55-63 (1988)

33. H. Groth and J. Lyman, Measuring performance changes in highly tran sient extreme heat stress: Rationale, problem, and experimental proce dures (Report No. AMRL-TDR-63-1). Wright-Patterson Air Force Base, Ohio: Air Force Systems Command (1963)

34. J. P. Guilford, The nature of human intelligence. New York: McGraw-Hill Book Company (1967)

35. T. H. Haig et al., Measurement of the discomfort component of illness. Medical Care. 27 (3), 280-287 (1989)

36. D. J. Hand and A. E. Reading, Discriminant function analysis of the McGill Pain Questionnaire. Psychological Report. 59 (2 Pt. 2), 763-770 (1986)

37. P. Harber et al., Nurse's beliefs about cause and prevention of occupa tional back pain. Journal of Occupational Medicine. 30 (10), 797-800 (1988)

38. E. C. Huskisson, Visual analogue scales. Pain Measurement and Assess ment. 33-37 (1983)

39. R. Jamison et al., Use of sensory descriptors in assessing chronic pain patients. Journal of Psychosomatic Research. 31 (5), 647-652 (1987)

40. L. F. Jarvik et al., Morphine, experimental pain, and psychological reactions. Psychopharmacology. 75, 124-131 (1981)

41. A. Jerome et al., Cluster headache pain vs. other vascular headache pain: Differences revealed with two approaches to the McGill Pain Questionnaire. Pain. 34 (1), 35-42 (1988)

42. R. K. Klepac et al., Sensitivity on the McGill Pain Questionnaire to intensity and quality of laboratory pain. Pain. 10, 199-207 (1981)

43. G. A. Korbon et al., The development of a somatic amplification rating scale for low-back pain. Spine. 12 (8), 787-791 (1987)

44. E. F. Kremer et al., Behavioral approaches to treatment of chronic pain: The inaccuracy of patient self-report measures. Archives of Physical Medicine and Rehabilitation. 62, 188-191 (1981)

45. E. M. Laska et al., An analytic approach to quantifying pain scores. Pharmacotherapy. 6 (5), 276-282 (1986)

46. S. Lautenbacher et al., SDT analysis of experimental thermal pain, "signal" and "no-signal" being determined psychophysically. Perceptual Motor Skills 68 (3 Pt 2), 1019-1030 (1989)

47. G. F. Lawlis el al., The development of the Dallas Pain Questionnaire. An assessment of the impact of spinal pain on Behavior. Spine 14 (5), 511-516 (1989)

48. D. Le Toulouse et al., Technique de psychologie experimentale. Paris: Octave Dion (1904)

49. W. Linden, Cardiovascular response as a function of predisposition, coping behavior and stimulus type. Journal of Psychosomatic Research. 29 (6), 611-620 (1985)

50. A. Love et al., Chiropractic chronic low back pain sufferers and self-report assessment methods. Part I. A reliability study of the Visual Analogue Scale, the Pain Drawing and the McGill Pain Questionnaire. Journal of Manipulative Physiological Therapy. 12 (1), 21-25 (1989)

51. T. Marek et al., Mental Fatigue at Work and Pain Perception. Work and Stress. 2 (2), 133-137 (1988)

52. T. G. Mayer et al., Progressive Isoinertial Lifting Evaluation. II. A Comparison with Isokinetic Lifting in a Disabled Chronic Low-Back Pain Industrial Population. Spine. 13 (9), 998-1002 (1988)

53. R. Melzack, The short-form McGill Pain Questionnaire. Pain. 30 (2), 191-197 (1987)

54. R. Melzack, The McGill Pain Questionnaire. Pain Measurement and Assessment. 41-47 (1983)

55. R. Melzack, The McGill Pain Questionnaire: Major properties and scoring methods. Pain. 1, 277-299 (1975)

56. R. Melzack and W. Torgerson, On the language of pain. Anesthesiology. 34, 50-59 (1971)

57. B. Mount et al., The management of intractable pain in patients with advanced malignant disease. The Journal of Urology. 120, 720-725 (1978)

58. O. Nyren et al., Self-rating of pain in nonulcer dyspepsia: A methodo logical study comparing a new fixed-point scale and the visual analogue scale. Journal of Clinical Gastroenterology. 9 (4), 408-414 (1987)

59. J. O'Brien and A. Francis, The use of next-of-kin to estimate pain in cancer patients. Pain. 35 (2), 171-178 (1988)

60. A. C. Papageorgiou and E. M. Badley, The quality of pain in arthritis: The words patients use to describe overall pain and pain in individual joints at rest and on movement. Journal of Rheumatology 16 (1), 106-112 (1989)

61. C. A. Pollard, Preliminary validity study of Pain Disability Index. Perceptual Motor Skills. 59, 974-976 (1984)

62. A. E. Reading, Comparison of pain rating scales. Journal of Psychoso matic Research. 24, 119-124 (1980)

63. A. Reading et al., The McGill Pain Questionnaire: A replication of its construction. British Journal of Clinical Psychology. 21, 339-349 (1982)

64. A. Reading et al., A comparison of response profiles obtained on the McGill Pain Questionnaire and an adjective checklist. Pain. 16, 375-383 (1983)

65. H. Riihimaki, Back pain and heavy physical work: A comparative study of concrete reinforcement workers and maintenance house painters. British Journal of Industrial Medicine. 42 (4), 226-232 (1985)

66. A. Satow and S. Taniguchi, The development of a motor performance method for the measurement of pain. Ergonomics. 32 (3), 307-316 (1989)

67. K. Sedlak, Low-back pain perception and tolerance. ain. 21, 440-444 (1985)

68. D. A. Shugars et al., Musculoskeletal back pain among dentists. General Dentistry. 32, 481-485 (1984)

69. J. Sperrazza and J. Blair, Evaluation of wound data and munitions effectiveness in Vietnam, Vol. I, Dept. of Defense Technical Report 1357, (DTIC No. AD 879516) 1970

70. J. Sprock et al., The relationship of depression and though disorder in pain patients. British Journal of Medical Psychology. 56, 351-360 (1983)

71. J. Stein and G. Mendl, The German counterpart to McGill Pain Question naire. Pain. 32 (2), 251-255 (1988)

72. M. J. Stevens et al., Modifying acute pain by matching cognitive style with cognitive treatment. Perceptual Motor Skills. 65 (3), 919-924 (1987)

73. P. C. Stomper et al., Is mammography painful? A multicenter patient survey. Archives of Internal Medicine. 148 (3), 521-524 (1988)

74. D. A. Stubbs et al., Back pain in the nursing profession. II. The effectiveness of training. Ergonomics. 26 (8), 767-779 (1983)

75. P. Sturmey et al., Psychometric properties of the Pain Assessment Questionnaire. British Journal of Clinical Psychology. 27 (Pt. 2), 183-184 (1988)

76. J. E. Sutherland et al., Differences and similarities between patient and physician perceptions of patient pain. Family Medicine. 20 (5), 343-346 (1988)

77. J. I. Szekely et al., Effects of D-Met,^{2} Pro^{5} -enkephalinamide on pain tolerance and some cognitive functions in man. Psychopharmacology. 89, 409-413 (1986)

78. R. C. Tait et al., The Pain Disability Index: Psychometric and validity data. Archives of Physical Medicine and Rehabilitation. 68 (7), 438-441 (1987)

79. M. Tamburini et al., Semantic descriptors of pain. Pain. 29 (2), 187-193 (1987)

80. S. Taniguchi and A. Satow, Pilot study for objective measurement of pain: method and analyses of basic factors for normative data. Perceptual Motor Skills. 66 (1), 147-157 (1988)

81. M. E. Taylor, Return to work following back surgery: A review. American Journal of Industrial Medicine. 16 (1), 79-88 (1989)

82. W. H. Teichner and J. L. Kobrick, Effects of prolonged exposure to low temperature on visual motor performance, flicker fusion and pain sensitivity (Report No. 230). Natick, Massachusetts: Quartermaster Research and Development Command (1954)

83. T. C. Toomey et al., Special validity of pain: A descriptive characteristic of chronic pain. Pain. 16, 296-300 (1983)

84. W. S. Torgerson and M. BenDebba, The structure of pain descriptors. Pain Measurement and Assessment. 49-54 (1983)

85. D. C. Turk and H. Flor, Pain greater than pain behaviors: The utility and limitations of the pain behavior construct. Pain. 31 (3), 277-295 (1987)

86. D. C. Turk et al., The McGill Pain Questionnaire reconsidered: confirming the factor structure and examining appropriate uses. Pain. 21, 385-397 (1985)

87. N. E. Walsh et al., Normative model for cold pressor test. American Journal Physical Medicine and Rehabilation. 68 (1), 6-11 (1989)

88. D. Wechsler, Manual for the Wechsler Adult Intelligence Scale. New York: Psychological Corporation (1955)

89. D. J. Wilkie et al., Use of the McGill Pain Questionnaire to measure pain: A meta-analysis. Nursing Research. 39 (1), 36-41 (1990)

90. R. C. Williams, Toward a set of reliable and valid measures for chronic pain assessment and outcome research. Pain. 35 (3), 239-251 (1988)

91. B. Wolf, Behavioral measurement of human pain. In Sternbach, R. A. (ed). Psychology of Pain. New York: Raven Press. 129-168 (1978)

APPENDIX

LISTING OF SYMPTOM COMPLEXES

1. Vomited once or twice; nauseated and may vomit again.

*2. Vomited several times including dry heaves; severely nauseated and will soon vomit again; exhausted with almost no strength; faints upon standing quickly; joints ache, considerable sweating; moderate fever; does not want to eat; sores in mouth and throat.

3. Very tired and weak.

*4. Vomited several times including dry heaves; severely nauseated and will soon vomit again; exhausted with almost no strength; unsteady upon standing quickly.

*5. Upset stomach; clammy and sweaty; mouth waters and swallows frequently; tired, with moderate weakness; strength somewhat reduced.

6. Vomits once or twice; (up to 4 episodes); nauseated and may vomit again; tired, with moderate weakness.

7. Nauseated; considerable sweating; swallows frequently to avoid vomiting.

8. Nauseated; considerable sweating; swallows frequently to avoid vomiting; tired, with moderate weakness.

*9. Vomited several times including dry heaves; severely nauseated and will soon vomit again; exhausted with almost no strength; slightly light-headed; fever and headache--like starting to come down with flu; very dry mouth and throat; rapid heartbeat and may faint with moderate exertion.

10. Vomited once or twice; nauseated and may vomit again; very tired and weak; thirsty and has dry mouth; weak and faint.

*11. Vomited several times including dry heaves; severely nauseated and will soon vomit again; occasional diarrhea, recently defecated and may again; exhausted with almost no strength.

12. Somewhat tired with mild weakness.

*13. Vomited several times including dry heaves; severely nauseated and will soon vomit again; very tired and weak.

14. Nauseated; considerable sweating; swallows frequently to avoid vomiting; tired, with moderate weakness; thirsty and has dry mouth; weak and faint.

*15. Nauseated; considerable sweating; swallows frequently to avoid vomiting; exhausted with almost no strength; very dry mouth and throat; headache; rapid heartbeat and may faint with moderate exertion.

*16. Vomited several times including dry heaves; severely nauseated and will soon vomit again; tired, with moderate weakness.

*17. Feels uncomfortable urge to defecate; tired, with moderate weakness.

*18. Nauseated; considerable sweating; swallows frequently to avoid vomiting; occasional diarrhea and cramps, defecated several times and will again soon; very tired and weak; slightly light-headed; joints ache, considerable sweating; moderate fever; does not want to eat; sores in mouth/throat.

19. Tired, with moderated weakness.

20. Vomited several times including dry heaves; severely nauseated and will soon vomit again; feels uncomfortable urge to defecate.

*21. Tired, with moderate weakness; mild fever and headache--like starting to come down with flu.

*22. Upset stomach; clammy and sweaty; mouth waters and swallows frequently.

*23. Upset stomach; clammy and sweaty; mouth waters and swallows frequently; feels uncomfortable urge to defecate; very tired and weak.

*24. Vomited once or twice; nauseated and may vomit again; exhausted with almost no strength; unsteady upon standing quickly; extremely dry mouth, throat, skin and very painful headache; has difficulty moving; short breath; burning eyes and skin.

25. Nauseated; considerable sweating; swallows frequently to avoid vomiting; somewhat tired with mild weakness.

26. Nauseated; considerable sweating; swallows frequently to avoid vomiting; very tired and weak; thirsty and has dry mouth; weak and faint.

*27. Nauseated; considerable sweating; swallows frequently to avoid vomiting; very tired and weak; very dry mouth and throat, headache; rapid heartbeat and may faint with moderate exertion.

28. Vomited once or twice; nauseated and may vomit again; somewhat tired with mild weakness.

*29. Vomited once or twice; nauseated and may vomit again; very tired and weak.

*30. Vomited several times including dry heaves; severely nauseated and will soon vomit again; feels uncomfortable urge to defecate; exhausted with almost no strength.

*31. Mild fever and headache--like starting to come down with flu.

*32. Somewhat tired with mild weakness; mild fever and headache--like starting to come down with flu.

33. Upset stomach; clammy and sweaty; mouth waters and swallows frequently; somewhat tired with mild weakness.

*34. Somewhat tired with mild weakness; joints ache, considerable sweating; moderate fever; does not want to eat; sores in mouth/throat.

*35. Joints ache, considerable sweating; moderate fever; does not want to eat; sores in mouth/throat.

*36. Tired, with moderate weakness; joints ache, considerable sweating; moderate fever; does not want to eat; sores in mouth/throat.

*37. Upset stomach; clammy and sweaty; mouth waters and swallows frequently; very tired and weak; thirsty and has dry mouth; weak and faint.

38. Nauseated; considerable sweating; swallows frequently to avoid vomiting; very tired and weak.

*39. Upset stomach; clammy and sweaty; mouth waters and swallows frequently; very tired and weak; very dry mouth and throat; headache; rapid heartbeat and may faint with moderate exertion.

40. Tired and weak; thirsty and has dry mouth; weak and faint.

Note: Those with an asterisk (*) include key words which may possibly denote pain.

Taken from Table B.2. List of symptom complexes used on questionnaires of Glickman et al. (1984).

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ATTN: S YANIV

DEPARTMENT OF DEFENSE CONTRACTORS

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ATTN: A DEVERILL

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ATTN: F GREY

HORIZONS TECHNOLOGY, INC
ATTN: J MARSHALL-MISE

KAMAN SCIENCES CORP
ATTN: DASIAC

KAMAN SCIENCES CORPORATION
ATTN: R STOHLER

KAMAN SCIENCES CORPORATION
ATTN: DASIAC

LOCKHEED MISSILES & SPACE CO, INC
ATTN: WE-YOUNG WOO

LOGICON R & D ASSOCIATES
ATTN: DOCUMENT CONTROL
ATTN: DOUGLAS C YOON

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MICRO ANALYSIS AND DESIGN
ATTN: R LAUGHERY

MISSION RESEARCH CORP
ATTN: DR NEIL GOLDMAN

PACIFIC-SIERRA RESEARCH CORP
2 CYS ATTN: G ANNO
ATTN: H BRODE

PACIFIC-SIERRA RESEARCH CORP
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TECHNICO SOUTHWEST INC
2 CYS ATTN: A S GLICKMAN
2 CYS ATTN: G L GAMACHE
15 CYS ATTN: S LEVIN

TRW OGDEN ENGINEERING OPERATIONS
ATTN: D C RICH

TRW SPACE & DEFENSE SECTOR
ATTN: DR BRUCE WILSON

UNIVERSITY OF CINCINNATI MEDICAL CENTER
ATTN: E SILBERSTEIN