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**AIRCREW/GROUNDCREW LIFE SUPPORT SYSTEMS RESEARCH
VOLUME 2: CLIN 0002 TASK ORDER REQUIREMENTS**

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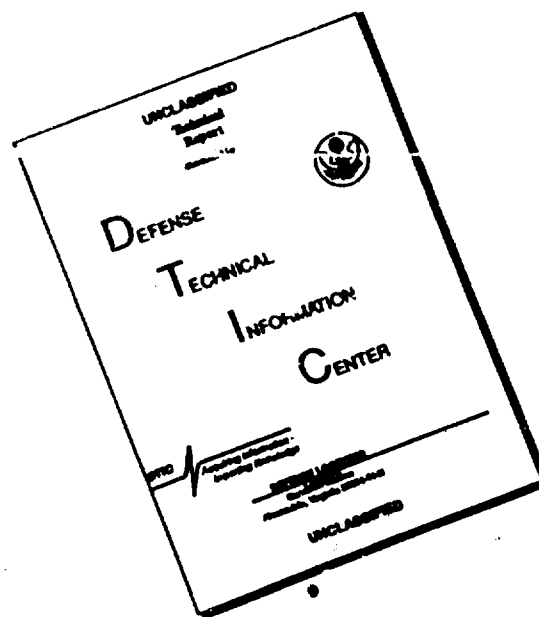
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The voluntary, fully informed consent of the subjects used in this research was obtained as required by AFR 169-3.

The animals involved in this study were procured, maintained, and used in accordance with the Animal Welfare Act and the "Guide for the Care and Use of Laboratory Animals" prepared by the Institute of Laboratory Animal Resources - National Research Council.

The Office of Public Affairs has reviewed this report, and it is releasable to the National Technical Information Service, where it will be available to the general public, including foreign nationals.

This report has been reviewed and is approved for publication.



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PREFACE

KRUG Life Sciences, Incorporated, has provided scientific, engineering, and technical support for the Armstrong Laboratory in accordance with task order requirements under CLIN 0002 of USAF Contract #F33615-89-C-0603. This final report provides summaries of objectives and accomplishments including citations and abstracts for the publications documenting the work. Reports which were not published in the open literature or as USAF Technical Reports or Technical Papers have been presented to the Armstrong Laboratory Technical Monitor for inclusion in the contract file or as attachments to equipment manuals where appropriate.

The following authors contributed substantially to the contractual effort by publishing the results of their efforts: Mr. F. A. Aldape, Dr. Melchor J. Antunano, Dr. Deborah L. Armstrong, Ms. Nancy J. Balkus, Ms. Judy L. Barber, Mr. Douglas J. Coffee, Ms. Jemett L. Desmond, Mr. William R. Ercoline, Mr. Samuel Galindo Jr., Mr. John R. Garza, Ms. Kathryn Hart, Ms. Cristine L. Heaps, Mr. Richard A. Howard, Dr. Robert W. Krutz, Jr., Mr. Sean A. McLean, Mr. John Ohlhausen, Dr. Robert M. Olson, Mr. Robert E. Simpson, Dr. Barbara J. Stegmann, Dr. Donald C. Teas, Dr. James T. Webb, Dr. Lisa F. Weinstein, and Ms. Janet F. Wiegman. The author cross-reference in Part D allows the reader to find the task report contributions of each author.

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LIST OF SYMBOLS, ABBREVIATIONS, AND ACRONYMS

AOI	Acoustic Orientation Instrument
AL	Armstrong Laboratory (formerly USAFSAM)
ATAGS	Advanced Technology Anti-G Suit
CFB	Cerebral Blood Flow
DCS	Decompression Sickness
G-LOC	G-Induced Loss of Consciousness
HUD	Head-Up Display
LES	Launch-Entry Suit
MSOGS	Molecular Sieve Oxygen Generating System
NASP	National Aerospace Plane
RDT&E	Research, Development, Test, and Evaluation
REAGS	Reentry Anti-G Suit
REOS	Regulated Emergency Oxygen System
SAC	Small Animal Centrifuge
SCN	Suprachiasmatic Nucleus
SOAR	Space Operations and Applications Research
USAF	United States Air Force
USAFSAM	United States Air Force School of Aerospace Medicine
VGE	Venous Gas Emboli

AIRCREW/GROUNDCREW LIFE SUPPORT SYSTEMS RESEARCH

VOLUME 2: CLIN 0002 TASK ORDER REQUIREMENTS

PART A:

INTRODUCTION

James T. Webb and Robert W. Krutz, Jr.

USAF Contract F33615-89-C-0603 (SOW Section 3.3; CLIN 0002) with KRUG Life Sciences, Incorporated, supported the Crew Technology Division, Armstrong Laboratory, by providing for research support in the form of professional and technical personnel, resources, and when required, facilities necessary to accomplish task orders for research, development, test and evaluation (RDT&E), to include, but not be limited to the following topics: chemical defense, experimental aeromedical and casualty care equipment, laboratory support, biochemical laboratory support, test studies and evaluations, system integration/equipment modification, equipment design package, independent engineering tests, equipment fabrication, design and development, computer programs, specialized and unique R&D laboratory facilities, and altitude research. This final report is a summary of the contract CLIN 0002 objectives and accomplishments.

PART B:

SUMMARY OF OBJECTIVES AND ACCOMPLISHMENT

Note: The objective (or a summary of the objective and description of work) and accomplishments for each task order are presented here in the same sequence as the task order numbers. Task Order Numbers 0006, 0007, 0011, 0022, 0025, 0027, 0029, and 0033 were not activated and are therefore omitted in this outline system to facilitate subparagraph numbering synonymous with Task Order Numbering.

B.1 Task 0001. ATAGS Anti-G Suit Fabrication

B.1.1 Objective

KRUG Life Sciences, Incorporated, was tasked to produce 12 ATAGS suits incorporating the modifications as specified under the Description of Work section and any other modifications required for centrifuge and flight test evaluation. KRUG was also to support the centrifuge testing of these suits and make further adjustments and modifications of the advanced technology anti-G suit (ATAGS) suits as defined during testing.

B.1.2 Accomplishments

The ATAGS suits were constructed and tested as described in the following technical report.

Simpson RE, Ohlhausen J. Advanced technology anti-G suit (ATAGS) fabrication. (Limited distribution) USAFSAM-TR-90-32. 1990:65pp.

Abstract (abstract [only] released from distribution limitation): "The development and testing of twelve extended coverage G-suits is addressed in this report. These suits were proven superior to the current CSU-13/BP suits at Edwards AFB during flight trials in 1988. Utilizing the comments from the pilots in the 1988 flight trials, the suits discussed in this report improved comfort, donning/doffing and mobility without sacrificing performance. An account of the conceptual, developmental and testing stages of the extended coverage G-suits, i.e., the Advanced Technology Anti-G Suit (ATAGS), is provided."

B.2 Task 0002. Psychoacoustic Support - AOI

B.2.1 Objective

KRUG Life Sciences, Incorporated, was tasked to provide the scientific quality control needed to efficiently select a set of candidate auditory displays that will be evaluated for possible use in aircraft. This work is to directly support the development and evaluation of the Acoustic Orientation Instrument (AOI) by the USAF School of Aerospace Medicine.

B.2.2 Accomplishments

The results of this effort are described in the following reports.

Lyons TJ, Gillingham KK, Teas DC, Ercoline WR, Oakley C. The effects of acoustic orientation cues on instrument flight performance in a flight simulator. AGARD, Conference Proceedings No. 478, Situational Awareness in Aerospace

Operations, L-6, Copenhagen, Denmark 1989. Aviat. Space Environ. Med. 1990;61:699-706.

Abstract: "An initial version of an acoustic orientation instrument (AOI), in which airspeed was displayed as sound frequency, vertical velocity as amplitude modulation rate, and bank angle as right-left lateralization, was evaluated in a T-40 (Link GAT-3) motion-based simulator. In this study, 15 pilots and 3 non-pilots were taught to use the AOI and flew simulated flight profiles under conditions of neither visual nor auditory instrumentation (NO INPUT), AOI signals only (AOI), T-40 simulator instrumentation only (VISUAL), and T-40 simulator instrumentation with AOI signals (BOTH). Bank control under AOI conditions was significantly better than under the NO INPUT condition for all flying tasks. Bank control under VISUAL conditions was significantly better than under the AOI condition only during turning and when performing certain complex secondary tasks. The pilots' ability to use the AOI to control vertical velocity and airspeed was less apparent. However, during straight-and-level flight, turns, and descents the AOI provided the pilots with sufficient information to maintain controlled flight. Factors of potential importance in using sound to convey aircraft attitude and motion information are discussed."

Teas DC. Review of audition literature: Selection of acoustic signals for use in the synthesis of auditory space. USAFSAM-TR-90-33. 1990:34pp.

Abstract: "The purpose of this review is to aid pilot interest in psychoacoustics that seem particularly relevant to the problem of synthesizing auditory space and presenting information within it. Included is a historical background with an orientation toward contemporary psychoacoustic information. Appendix A lists, with descriptors, the journal articles reviewed. Appendix B is a bibliography."

Teas DC, Ercoline WR, Lyons TJ, Gillingham KK. The Discriminability of Aircraft State Mediated by Acoustic Cues. (Abstract) Aviat. Space Environ. Med. 1990;61:505.

Abstract: "**INTRODUCTION:** Incidents of pilot disorientation might be reduced if the state of the aircraft could be made immediately evident, for example, by acoustic rather than by visual signals. **METHODS:** Voltages representing airspeed, bank angle and vertical velocity from a T-40 Link Trainer were used to drive a special purpose Acoustic Orientation Instrument (AOI). Repetition rate of a square wave was dependent upon airspeed, interneural intensity difference was dependent upon bank angle, and an asymmetrical amplitude modulation was dependent upon vertical velocity. Fifteen subjects were tested, 3 of whom were naive non-pilots. Subjects flew three conditions (primary tasks): level flight, level right turn at 30° bank, level descent at 1000 ft/m. These conditions were flown with NO INPUT, AOI only, VISUAL (the T-40 instruments) and, for the second experiment, BOTH visual and auditory. In the second experiment, subjects performed two additional (secondary) tasks: (1) change radio frequency and then the transponder code and (2) looking up a radio frequency and changing to that frequency. **RESULTS:** The AOI provided useful information about airspeed and bank angle. Thirteen Ss performed within 3° with respect to bank angle. The use of

both the AOI and VISUAL inputs led to some degradation in performance for the more difficult secondary task."

B.3 Task 0003. Regulated Emergency Oxygen System (REOS)

B.3.1 Objective

KRUG Life Sciences, Incorporated, was tasked to deliver a prototype REOS based on the furnished general design description and figures. KRUG Life Sciences, Incorporated, was to support all testing and evaluation of this system and make further modifications as defined during testing.

B.3.2 Accomplishments

The results of this effort are described in the following technical paper.

Balkus NJ, Hade EW, Ohlhausen J. Regulated Emergency Oxygen System. AL-TP-1992-0041. 1993:34pp.

Abstract: "This paper describes the accomplishments of the Regulated Emergency Oxygen System (REOS) task. A true emergency secondary oxygen system is nonexistent in current aircraft. The current system is inadequate in regulating pressure, is ineffective at altitudes below 10,000 ft and provides no option except to activate the emergency oxygen bottle if a malfunction of the primary regulator occurs. The REOS concept alleviates these inadequacies by providing an option to select a secondary regulated oxygen source, rather than the emergency bottle, if there is a malfunction of the primary regulator. Also of significance is that altitude protection has been incorporated in the REOS. The content of this paper provides greater details as to the background, development, and testing of the REOS."

B.4 Task 0004. E Chamber Defrost System Replacement

B.4.1 Objective

KRUG Life Sciences, Incorporated, was tasked to prepare for the E chamber defrost system reactivation by designing, fabricating, installing, and testing components of a cooling coil defrost system to interface with existing cooling coils associated with Chamber 9 in Building 160. The system was to include the operation of the ventilation/circulation fan, the warm-air system, and a system to view and store control data in real time.

B.4.2 Accomplishments

A hydraulic system was installed to interface with Chamber 9 in Building 160. The final report consisted of four engineering drawings (BHC-PD-0901-1, BHC-PD-0901-2, BHC-AL-0902-1, BHC-AL-0906-1) and documentation (pump manuals included in the technical manuals) for the hydraulic system installed under this task. The drawings and documentation were delivered to AL/CFTS (USAFSAM/VNS) and are located in Building 160 with the documentation for Chamber 9 (E Chamber; earlier nomenclature).

B.5 Task 0005. Breathing Resistance Testing/Mask Ventilation Tolerance

B.5.1 Objective

KRUG Life Sciences, Incorporated, was tasked to conduct a study, using contractor-furnished subjects, to assess physiological responses to varying levels of breathing resistance.

B.5.2 Accomplishments

The results of this effort are discussed in the following report.

Antunano MJ, Constable SH. Human response wearing the MCU-2/P groundcrew chemical defense mask. (Abstract) Aviat. Space Environ. Med. 1991;62:471.

Abstract: "INTRODUCTION. Resistance to breathing is a factor that determines individual tolerance to physical work while wearing a protective mask. The purpose of this study was to determine physiological and psychological effects of wearing the MCU-2/P mask. METHODS. Three mask configurations (MC) were tested: I) mask+1 filter, II) mask+2 filters, and III) mask+1 filter+powered air blower (=3.8 cfm). Six subjects were tested pedaling a bicycle ergometer at 2 consecutive workloads (60 & 120 watts). Each MC was tested at both workloads (5 min for each MC) for a total of 30 min. Physiological variables included heart rate, respiratory rate, minute volume, and inspiratory resistance. Rating of perceived exertion (RPE) and perceived inspiratory and expiratory effort were also measured. RESULTS. Heart rates, respiratory rates, minute volumes and RPE's showed a direct relationship with workload intensity but no relationship with any MC. As expected, the lowest inspiratory resistance was observed with MC-III, followed by MC-II and MC-I. Subjects experienced less breathing effort with MC-III, followed by a more modest reduction of breathing effort with MC-II. CONCLUSIONS. The best approach to reduce the physiological and psychological burden imposed by the MCU-2/P mask is to provide powered ventilation to the filter canister. Unfortunately, this creates some logistical problems during military operations. On the other hand, a more practical approach to cope with this problem may be to simply attach a second filter canister to the mask (even though this is comparatively less effective than using a powered air blower)."

Antunano MJ, Chen YT, Constable SH. Acute physiological responses while wearing various configurations of the MCU-2/P groundcrew chemical defense mask. AL-TR-1991-0138. 1992:28pp.

Abstract: "Resistance to breathing is a major factor that determines individual tolerance to physical work while wearing a protective mask. This study evaluated some of the acute effects associated with the use of the MCU-2/P mask. **METHODS.** Three MCU-2/P mask configurations (MC) were tested: mask + 1 filter (MCU-1F), mask + 2 filters in parallel (MCU-2F), and mask + 1 filter + air blower (MCU-1AB). The air blower provided $65 \text{ L} \cdot \text{min}^{-1}$ (2.3 cfm) of ambient air through the filter. Five subjects pedaled a cycle ergometer at 2 workloads (60 & 120 watts). Each MC was tested consecutively for 5 min under each workload, for a total of 30 min per experiment. Each subject repeated the experiment three times while randomizing the mask/workload test order. Variables measured included heart rate,

respiratory rate, tidal volume, minute volume, inspiratory & expiratory mask cavity pressures, perceived inspiratory & expiratory effort, and overall breathing discomfort. **RESULTS.** The lowest inspiratory resistance was observed with the MCU-1AB, followed by the MCU-2F and MCU-1F. Subjects experienced less breathing effort and discomfort with the MCU-1AB, followed by a more modest reduction with the MCU-2F. Heart rates, respiratory rates, tidal volumes, and minute volumes showed no correlation with the three levels of inspiratory resistance, but were related to workload. **CONCLUSIONS.** The best approach to reduce the respiratory burden imposed by the MCU-2/P mask is to provide powered ventilation through the filter. Unfortunately, this approach creates logistical problems. A more practical approach may simply be to attach a second filter canister to the mask."

B.8 Task 0008. Heart Period Variability Study

B.8.1 Objective

KRUG Life Sciences, Incorporated, was tasked to deliver and interpret heart period data from vagal tone monitoring, and support publication of data results. A written analysis was to be provided, including methodology and interpretation of the ASCII-format heart period data files. The files consisted of R-R interval data on 8 subjects, 3 flights each, monitored for 30 minutes each.

B.8.2 Accomplishments

The results of this effort are discussed in a report delivered to the Systems Research Branch of the Crew Technology Division which discusses a study of heart period variability during rapid decompression to 50,000 feet.

B.9 Task 0009. Neurochemical Correlates of Aerospace Stress

B.9.1 Objective

KRUG Life Sciences, Incorporated, was tasked to perform the required research in a biochemical analysis laboratory for the purpose of determining neurochemical correlates of aerospace stressors. This effort was to include the operation and maintenance of Waters HPLC units and other neurochemical/physiological analysis equipment.

B.9.2 Accomplishments

Technical support was provided for data acquisition resulting in the following papers.

Rea MA. Light increases fos-related protein immunoreactivity in the rat suprachiasmatic nuclei. Brain Res. Bull. 1989;23:577-81.

Werchan PM, Shahed AR. Brain biochemical factors related to G-LOC. Physiology. 1992;35:143-6.

The results of this technical support effort are included in the following papers.

Rea MA, Michel AM. Phase-specific distribution of light-induced fos immunoreactivity in the SCN. Soc. Neurosci. Abstr. 1990;16:771.

Abstract: "Male, Syrian hamsters were housed individually in activity cages and maintained under constant darkness for at least 10 days. Hamsters were exposed to 15 min of white light (33 lux) at either circadian time (CT)6, CT13 or CT18. Light exposure at these times resulted in phase shifts of the free running activity rhythm or -0.12 ± 0.12 hrs (no shift), -1.0 ± 0.2 hrs (phase delay) and $+1.9 \pm 0.8$ hrs (phase advance), respectively. Two hours after stimulation, groups of hamsters (n=8) were anesthetized and perfused with 4% paraformaldehyde. Serial 70 micron-thick sections containing the SCN were immunostained for c-fos protein (FOS) using antiserum provided by Dr M. Iadarola (NIDR). Light exposure at both CT13 and CT18 resulted in the appearance of FOS-immunoreactive (FOS-ir) cell nuclei in the suprachiasmatic hypothalamus. In CT13 animals, FOS-ir cells were confined to the SCN and concentrated within the ventrolateral aspect of the nucleus. In contrast, FOS immunostaining was more widespread in CT18 animals, with FOS-ir cells present throughout the SCN and extending dorsally into the surrounding hypothalamus. Stimulation at CT6 did not increase FOS-ir in the SCN. These data indicate that (1) c-fos expression in the SCN occurs in association with light-induced alterations in pacemaker activity and (2) different populations of cells in the suprachiasmatic hypothalamus are activated by retinal illumination at phase delay and phase advance times. Supported by AFOSR 2312W6 (MAR)."

Shahed AR, Aldape FA, Barber JA, Werchan PM. Physiological and Metabolic Changes During Gravity (+Gz) Induced Loss of Consciousness (G-LOC) in Rat Brain. (Abstract) Soc. Neurosci. Abstr. 1990;16:993.

Abstract: "High sustained or rapid onset of +Gz is known to cause G-LOC in pilots of high performance aircraft with potentially grave consequences. Relatively little is known about G-LOC and so approaches to its prevention are limited. In the present study a small animal centrifuge (SAC) was used to investigate the neurophysiological mechanism of G-LOC. Rats with surgically implanted electrodes for EEG, ECG and heart rate were loaded on a SAC equipped with a freeze blowing device. Control rats received identical surgical treatment but were not centrifuged. Rats were centrifuged for 30s at 1 to 32.5 Gz to determine G-tolerance and time for G-LOC to occur. Brains were frozen immediately (group 1), or 30-60s (group 2) after G exposures and analyzed for energy metabolites. At 25 ± 1 Gz (n=19), G-LOC was observed within 17 ± 1 s and EEG remained isoelectric for 15-24s. Brain glucose decreased (70%) in group 1 and remained unchanged in group 2 over controls. Brain lactate increased 2-2.5 fold over control in both groups. ATP and creatine phosphate levels decreased and AMP, ADP and adenosine levels increased significantly in both groups. This is the first report to show metabolic changes during G-LOC. Investigations continue to determine if these and/or other changes contribute to G-LOC."

Shahed AR, Barber JA, Aldape FA, Werchan PM. Acceleration induced effects on baboon blood chemistry. (Abstract) Aviat. Space Environ. Med. 1991;62:463.

Abstract: "INTRODUCTION. The phenomenon of G-induced loss of consciousness (G-LOC) is well recognized in pilots of high performance aircraft. A complete understanding of the mechanism of G-LOC is essential to prevent G-LOC and its potential effects on pilots. In this study, effects of multiple +Gz exposures on baboon blood chemistry are described. METHODS. Adult baboons (n=4) were anesthetized with ketamine and a heparinized PE 250 catheter was inserted into the jugular vein and connected to a syringe pump. EEG and ECG electrodes were attached the next day. The baboons were loaded on the USAFSAM centrifuge and exposed to 2, 4 and 6 +Gz for 30s with 15 min rest period after each run. The last exposure consisted of 4 consecutive runs of 4 +Gz for 15s each. Blood samples (3 ml) were collected before, during, 5 and 15 min after each run and for 3 additional hrs at 30 min interval after the last run. Samples were analyzed for blood gases, pH, creatine kinase activity, glucose, lactate and pyruvate. RESULTS. All 4 baboons experienced G-LOC at 6 G, 10 to 15s after the onset. Blood glucose, lactate and PO_2 tended to decrease during the run followed by an increase during recovery. There were slight variations in pH and PCO_2 but creatine kinase activity and pyruvate levels remained unchanged. CONCLUSION. The data show that during +Gz exposure glucose metabolism is altered. However, more work is needed to examine if any of these changes contribute to or are associated with G-LOC."

Werchan PM, Barber JA, Aldape FG, Shahed AR. Effect of a single high acceleration exposure of rats in a small animal centrifuge (SAC) on brain physiology and energy metabolism. (Abstract) J. Cereb. Blood Flow Metab. 1991;2(Suppl.2):5457.

Abstract: "Introduction: The problem of +Gz (head-to-foot) induced loss of consciousness (G-LOC) occurs occasionally in pilots of high performance aircraft, at or above +5 Gz, and results in about 12-15s of total and 16s of partial incapacitation (1). G-LOC presumably results from the diversion of cerebral blood flow towards the lower extremities. A centrifuge is used to study effects of high sustained G and G-LOC in humans. Additionally, straining maneuvers and G-protective garments are used to enhance G-tolerance of pilots. However, factors which contribute to G-LOC and its acute and/or chronic effects on brain physiology and metabolism remain unknown. This report presents an animal model to allow investigation of the G-LOC phenomenon at the cellular level. Methods: A 5' diameter, 5' tall SAC, capable of achieving +85 G, with +20 G/s onset and offset acceleration rate was used. The SAC is fully computer controlled and has 8 channels for data collection. The SAC has two tissue collection devices, a freeze brain blower and a 2450 MHz, 10 kW microwave heat inactivation system. Fully awake, male Sprague-Dawley rats (250-450g) with previously implanted EEG and ECG electrodes (under halothane anesthesia) were placed in a restrainer and secured on the SAC arm. Control rats (n=5) were exposed to base +1 Gz force for 30s and the brains were collected by freeze blowing on plates precooled in liquid N_2 . Experimental groups (n=5-7) were exposed to 10s at base +Gz and 30s at +25G except the G-LOC group. Brains were collected at the onset of G-LOC, end of the run and 1, 3, and 15 min after the run. G-LOC was defined as the point where EEG was isoelectric. Perchloric acid brain extracts were analyzed for glycolytic intermediates (enzymatic

methods) and high energy metabolites by ion pair reverse phase HPLC. Results: The data show that G-LOC was elicited after $14.5 \pm 3s$ at +25 Gz and EEG remained isoelectric for an additional 15-34s depending on the time of brain collection. Heart rate was significantly lower immediately after the 30s run than before. A significant increase in brain lactate, and a decrease in Cr-phos and ATP levels during and 1 min after G-LOC was observed. However, Cr-Phos, and ATP returned to control levels after 3 min and lactate by 15 min after the run respectively. The concentration of adenosine, a vasodilator, increased significantly over control. There was no significant change in glycogen level, but glucose concentration was lower than the control 1 min after the run. ADP and AMP levels were slightly higher than the control. Discussion: This study suggests that the SAC is a good tool to study effects of high +Gz on brain metabolism in rats. This is the first report to show transient changes in cerebral glucose and energy metabolism induced by a single high G exposure. These metabolic changes are similar to the results obtained when anesthetized rats were subjected to 15-60s of global ischemia by a 4-vessel occlusion model (unpublished observation). This suggests that G-LOC may result from transient global ischemia."

B.10 Task 0010, Bends Susceptibility

B.10.1 Objective

KRUG Life Sciences, Incorporated, was tasked to investigate five highly bends-susceptible and five highly bends-resistant individuals. Blood samples were to be taken by the contractor and assayed for anaphylatoxin levels by two methods and the better of these methods was to be identified.

B.10.2 Accomplishments

The results of this effort are discussed in the following technical report.

Webb JT, Pilmanis AA. Complement proteins and susceptibility to altitude-induced decompression sickness. (Abstract) Undersea Biomed. Res. 1992;19(Suppl.):52 and AL-TR-1992-0068. 1992:16pp.

Abstract: "Previous work implicated activation of complement proteins C5a and C3a by venous gas emboli (VGE) in the etiology of decompression sickness (DCS). The current effort used enzyme-immunoassay (EIA) methodology in addition to the radio-immunoassay (RIA) method previously used to determine the level of complement activation in blood plasma samples exposed to bubbles of air. Eight healthy male subjects who had histories of VGE-susceptibility when exposed to simulated altitudes above 20,000 ft were included in the study. Four subjects were DCS-resistant and four were DCS-susceptible. Ethylene-diamine-tetraacetic acid (EDTA) plasma samples from these subjects were split into equal parts and incubated for 30 min in polypropylene tubes at 37° C. Test samples were incubated in the presence of air bubbles, and control samples were incubated without bubbles. C3a (RIA) and iC3b (EIA) in bubbled samples were activated to levels of 386 ng/ml and 21.2 µg/ml (approximately 36% more than controls; $p < 0.05$). Significant activation of other proteins by bubbles or zymosan may have been inhibited by lack of sufficient

magnesium due to use of EDTA. Results from this limited sampling did not suggest a difference between complement activation in DCS-susceptible subjects and DCS-resistant subjects. The findings suggest a potential for use of EIA methodology in studying the effects of bubbles on human plasma and stress the need for further study to clarify the requirement for magnesium ions by proteins of the complement pathways."

B.12 Task 0012. USAFSAM Centrifuge Repair

B.12.1 Objective

KRUG Life Sciences, Incorporated, was tasked to install, adjust, and test a new set of drive gears and necessary seals on the USAFSAM Centrifuge to restore and/or improve this equipment to original design specification goals by contract effort. KRUG Life Sciences, Incorporated, was to ensure that all work in association with this task was in accordance with Government requirements to include proper centrifuge operation at the conclusion of the effort. Specifications per these Government requirements was to be provided to KRUG Life Sciences, Incorporated, by the Government at the beginning of the task order.

B.12.2 Accomplishments

The drive gears were installed and tested as described above. Documentation of the calculations, engineering drawings, specifications, test results, and modifications accomplished during this effort are filed with the Armstrong Laboratory Centrifuge Technical Orders which are kept in the centrifuge data collection area.

B.13 Task 0013. Metabolic Monitoring of Hypobaric Research Subjects

B.13.1 Objective

KRUG Life Sciences, Incorporated, was tasked to quantify the metabolic activity of subjects during isometric and isotonic exercise in order to develop individualized procedures for exercise performance during simulated high altitude exposures.

B.13.2 Accomplishments

The results of this effort are described in the following technical report.

Wiegman JF, McLean SA, Olson RM, Pilmanis AA. Metabolic monitoring of hypobaric research subjects. AL-TR-1991-0057. 1993:44pp.

Abstract: "The objective of Task Order No. 0013, amendment to USAF Contract No. F33615-89-C-0603, was to quantify the metabolic activity of subjects during isometric and isotonic exercise to develop procedures for individualized exercise performance during simulated high altitude exposures. To satisfy the stated objective, KRUG Life Sciences, Incorporated, performed the following tasks: 1) designed and instrumented a stack-weight machine suitable for isometric or isotonic exercise performed with the arm or legs; 2) provided and operated an advanced metabolic measurement system capable of breath-by-breath analysis of low-level oxygen consumption data; 3) provided for administration of criterion tests for maximal oxygen

consumption (VO_{2max}) and maximal voluntary contraction; 4) developed procedures for equating and individualizing the isometric and isotonic work by means of oxygen consumption (% of VO_{2max}); and 5) provided procedures for training subjects on the individual exercise programs."

B.14 Task 0014. Operational Thermal Stress Fatigue Predictions

B.14.1 Objective

KRUG Life Sciences, Incorporated, was tasked to accomplish a thorough review of AFR 355-8 and supporting documents; making recommendations for revision of AFR 355-8.

B.14.2 Accomplishments

This effort reviewed AF Regulation 355-8 (work/rest cycle guidance in MOPP), current US Army guidance, and calculated new W/R cycle estimations using the MIPPS thermal model (Comfort Technology, Inc.). The effects of both personal microclimate cooling and dehydration/fluid intake on physiological performance were addressed. Some of this information was presented in various formats for comparison purposes. An attempt was also made to extrapolate the predicted level of heat storage to estimates of thermal casualties. Selected information from this work will be included in a forthcoming technical report which will recommend revisions to AFR 355-8.

B.15 Task 0015. Skeletal Muscle Respiratory Function Analysis

B.15.1 Objective

KRUG Life Sciences, Incorporated, was tasked to provide a better understanding of the physiology and potential pathophysiology of thermal stress at the cellular level.

B.15.2 Accomplishments

Technical support was provided for acquisition of data which were incorporated in the following report.

Walters TJ, Constable SH. The effect of intermittent cold exposure on the fiber type composition of selected skeletal muscles in rats. (Abstract) Med. Science. Sports Exerc. 1991;23(Suppl.):S130.

B.16 Task 0016. Neurochemistry of Photic Entrainment

B.16.1 Objective

KRUG Life Sciences, Incorporated, was tasked to acquire neurophysiological data relating to the viability and structural integrity of the RHT and SCN in individual hypothalamic slices.

B.16.2 Accomplishments

The results of this effort are described in the following technical report.

Armstrong DL, Hart K, Rea MA. Suprachiasmatic nucleus responses to retinohypothalamic tract stimulation in a rat brain slice preparation. AL-TP-1992-0008. 1992:20pp

Abstract: "Field potentials in the suprachiasmatic nucleus (SCN) were evoked by stimulation of the optic tract using an *in vitro* slice preparation of the rat hypothalamus.

Stimulation of the contralateral optic nerve produced responses that consisted of a short latency negative wave followed by a second, longer-lasting negative wave. Experiments conducted under low calcium conditions in the slice perfusate established that the second negative wave represented potentials generated postsynaptically. Both pre- and postsynaptic components of the response were abolished in the presence of 1 μ M tetrodotoxin. Bath application of 0.5 mM phaclofen increased the SCN response amplitude. These results suggest that SCN neuron responses to retinohypothalamic tract excitatory input are modulated by gamma-aminobutyric acid (GABA) B receptor activity."

B.17 Task 0017. Support of Auditory Spatial Orientation Display Development

B.17.1 Objective

KRUG Life Sciences, Incorporated, was tasked to conceive, generate, and psychophysically analyze candidate auditory displays that will be evaluated for possible use in aircraft. This work was to be directly in support of the development and evaluation of the Acoustic Orientation Instrument (AOI) by USAFSAM/VNBB.

B.17.2 Accomplishments

The results of this effort are described in the following technical report.

Gillingham KK, Teas DC. Flight evaluation of an Acoustic Orientation Instrument (AOI). (Abstract) Aviat. Space Environ. Med. 1992;63:441.

Abstract: INTRODUCTION: The AOI provides an auditory display of primary flight parameters, in theory allowing the pilot to maintain spatial orientation while visually occupied with other tasks. A flight simulator-tested AOI, which displays airspeed and vertical velocity as variable auditory images, and bank angle as lateralization of those images, was evaluated in flight in a Beech Queen Air aircraft. METHODS: The performance of 8 instrument-rated pilots during five experimental maneuvers (straight and level, 30° banked turn, steep turn, level-off from descent, and recovery from a disorienting and blind + AOI) was measured with respect to absolute vertical velocity and bank angle deviations (mean, RMS, and variance). ANOVA and post-hoc statistical comparisons of the four conditions were accomplished. RESULTS: In all maneuvers the blind + AOI condition resulted in significantly better ($p < 0.05$) bank angle control than was obtained in the blind-only condition, and bank angle control in the blind + AOI condition was not significantly different from that obtained under either hood condition. Although vertical velocity control tended to be better in the blind + AOI than in the blind only condition in most maneuvers, statistical significance was reached only in straight and level flight. CONCLUSION: The AOI enables a pilot to maintain bank angle control in the absence of vision. Its potential to aid in vertical velocity control is also evident, but the vertical velocity display needs to be improved."

Neubauer JC, Teas DC, Gillingham KK, Murphy P. Reference mode effect on the auditory display of aircraft bank angle. AL-TR-1991-0121. 1992:36pp.

Abstract: "This report describes a study which examined flight performance of instrument-rated pilots using only an auditory bank angle display with outside-in and inside-out display reference modes. In Part I, the subjects maintained straight and level flight of the T-40 simulator for 2 min. In Part II, the subjects returned the simulator to straight and level flight from a pseudo-random sequence of preset bank angles. Display reference mode made little difference on performance; however, stimulus factors were found to be important determiners of an auditory frame of reference within which events are placed."

B.18 Task 0018, Neuropharmacology of Light-Induced Gene Expression in the Suprachiasmatic Nucleus

B.18.1 Objective

KRUG Life Sciences, Incorporated, was tasked to conduct a detailed investigation of the neurochemical basis of light-induced and optic nerve stimulation-induced gene expression in the SCN of intact hamsters and rat brain hypothalamic slices, respectively. KRUG Life Sciences, Incorporated, was to be specifically concerned with the effects of (1) excitatory amino acid agonists and antagonists, (2) GABA agonists and antagonists, and (3) cyclic nucleotide, phosphoinositide, and arachidonic acid derived second messengers on stimulated expression of the c-fos proto-oncogene using both the in vivo and in vitro models. Finally, KRUG was to conduct experimentation concerning the biochemical nature of the daytime period of insensitivity of the circadian pacemaker to light stimulation.

B.18.2 Accomplishments

Technical support was provided for data acquisition resulting in the following papers.

Rea MA. Different populations of cells in the suprachiasmatic nuclei express c-fos in association with light-induced phase delays and advances of the free-running activity rhythm in hamsters. Brain Res. 1992;579:107-12. [T.O. 18]

Rea MA, Buckley B, Lutton LM. The neurochemical basis of photic entrainment of the circadian pacemaker. Proceedings of the Fifth Annual Space Operations and Applications Research (SOAR '91) Symposium, NASA Conf. Pub. 3127. 1992;2:476-81.

Rea MA, Buckley B, Lutton LM. Local administration of EAA antagonists blocks light-induced phase shifts and c-fos expression in the hamster SCN. Am. J. Physiol. 1993 [In Press].

The results of this effort are described in the following report.

Rea MA, Buckley B, Michel AM, and Lutton LM. Local administration of CNQX attenuates light-induced phase advances of the circadian activity rhythm and fos expression in the hamster SCN. (Abstract) Soc. Neurosci. Abstr. 1991;17:668.

Abstract: "Male, Syrian hamsters were fitted with guide cannulas stereotaxically aimed at the SCN and were housed in

constant darkness. Five minutes prior to photic stimulation (10 min pulse; 20-40 lux) at CT18.5, animals received 300 nl injections of either 1 mM CNQX or vehicle into the suprachiasmatic hypothalamus. Light pulses induced phase advances of 81 ± 8 min. Vehicle injections reduced shifts ($p < 0.01$) by 33% to 54 ± 10 min. However, CNQX completely blocked light-induced phase advances in most animals (12 ± 9 min; $n=9$). Furthermore, CNQX reduced the number of c-fos protein (FOS)-immunoreactive cells in the SCN of light-stimulated hamsters by 30% ($p < 0.05$). This effect was most pronounced on the side of the injection (329 ± 63 vs 548 ± 55 cells). Vehicle injections did not affect light-induced c-fos expression in the SCN. These results are consistent with the hypothesis that light-induced phase alterations of the SCN circadian pacemaker are mediated by excitatory amino acids and may require the expression of FOS-dependent genes. Supported by AFOSR 2312W6 (MAR)."

B.19 Task 0019, CWD Research Support

B.19.1 Objective

KRUG Life Sciences, Incorporated, was tasked to evaluate the optimal effects of work/rest cycles, breathing resistance, protective ensemble modifications, and personal microclimate cooling on human performance. The two experimental approaches were to include both in vivo human or small animal testing and computer modeling.

B.19.2 Accomplishments

The results of this effort are described in the following report.

Antunano MJ, Baumgardner FW, Chen YT, Constable SH. Characterization of chemical defense mask breathing resistance tolerances. AL-TP-1992-0061. 1993:44pp.

Abstract: "The purpose of this study was to evaluate the effects of wearing MCU-2/P and M-17 groundcrew chemical defense masks during steady-state work. Five MCU-2/P mask configurations (MC) were tested: mask without filter (MCU-OF), mask + 1 filter (MCU-1F), mask + 2 filters (MCU-2F), mask + 1 filter + air blower A (MCU-ABA), and mask + 1 filter + air blower B (MCU-ABB). Ten subjects walked on a treadmill (3 mph - 5.0% grade) for 1 hr wearing each MC. Variables measured included inspiratory and expiratory mask cavity pressures (IMCP & EMCP), mask cavity pressure-swing (MCPS), peak inspiratory airflow rate (PIAFR), respiratory rate (RR), peak tidal volume (PTV), minute volume (MV), heart rate (HR), rating of perceived exertion (RPE), perceived inspiratory and expiratory effort (PIE & PEE), and overall breathing discomfort (OBD). Each MC was characterized by a significantly different IMCP. The MCU-ABA produced the lowest IMCP, while MCU-1F produced the highest. The MCU-2F reduced inspiratory resistance by about 47%. There were no significant differences in PIAFR, RR, PTV, MV, RPE, PIE, PEE and OBD among the various MC. The new MCU-2/P mask does improve total breathing resistance over the standard M-17 mask. Neither mask should induce significant cardiorespiratory strain providing the physical work is of low intensity. A very effective (but logistically difficult) approach to reduce the level of inspiratory resistance imposed by the MCU-2/P mask is to

provide powered ventilation as compared to the relatively simple installation of a second filter."

Heaps CL, Howard RA, Constable SH. An exercising primate model for the evaluation of selected occupational stressors. (Abstract) Med. Sci. Sports Exerc. 1992;24(Suppl.):S132.

Abstract: "The purpose of the present research was to characterize the physiological effects of some potential military stressors such as work and increased environmental heat load in rhesus monkeys. This multi-dimensional primate model has been developed for safety and ethical reasons as human research in this area cannot always be performed. These primates (N=6) were behaviorally conditioned to exercise in a wheel ergometer at ~3 METs. On separate days, each monkey attempted six work/rest cycles (10 min work:1 min rest) at 15, 25 and 35 °C (T_{db}), vapor pressure < 10 mm Hg. Rectal temperature (T_{re}), body weight (BW) and blood samples were taken immediately before and after exercise. Excessively high heat storage rates dictated that the 35 °C trial be limited to three work/rest bouts. The change in T_{re} (mean $\pm$ SE) during exercise was significantly different in the 35 °C trial than during 15 and 25 °C ($+1.69 \pm 0.3$ °C vs. -0.46 ± 0.2 °C and $+0.19 \pm 0.2$ °C, respectively). Sweat rate, as determined by the change in BW over time, was significantly greater during the 35 °C trial as compared to the 15 and 25 °C trials (2.39 ± 0.2 vs. 0.97 ± 0.1 and 1.33 ± 0.1 g/min, respectively). No significant differences in fasting blood glucose existed between trials. However, post blood glucose in the 35 °C trial differed significantly from the 15 and 25 °C values: a result of the shortened exercise time. Pooled blood glucose levels (15 and 25 °C trials) significantly declined during exercise from 79.5 ± 4.8 mg/dl to surprisingly low levels of 31.9 ± 3.5 mg/dl. Very modest increases in blood lactate ($\Delta = 1-2$ mmol) were observed independent of environmental temperature. The findings of this study indicate that the increased heat storage observed at higher environmental heat loads appears to limit the amount of work these primates can perform, possibly the result of a limited maximal sweat production capacity. Additionally, blood glucose following exercise decreased to levels not typically seen in humans."

B.20 Task 0020. Chamber 9 Chiller System Modification

B.20.1 Objective

KRUG Life Sciences, Incorporated, was tasked to design, fabricate, install, and test a chiller system modification in Chamber 9 to interface with the existing cooling coils. The system was to include a cooling media defrost subsystem and a chiller compressor control subsystem.

B.20.2 Accomplishments

The chiller system modification was accomplished and documentation on equipment and software was incorporated in the Chamber 9 operating manuals.

B.21 Task 0021. Non-radioactive Method for the In Situ Quantitation of Specific Messenger RNA using Colloidal Gold

B.21.1 Objective

KRUG Life Sciences, Incorporated, was tasked to conduct studies directed toward the development of a nonradioactive technique for in situ quantitation of specific messenger RNA in brain slices using colloidal gold particles.

B.21.2 Accomplishments

The results of this effort are described in the following technical paper.

van den Pol AN, Rybczinski R. Nonradioactive approaches to gene detection. AL-TP-1993-0007. 1993:24pp.

Abstract: "Several new procedures for nonradioactive in situ detection of mRNA both in fixed histological sections and in living cells were evaluated. The use of cDNA and cRNA probes labeled with: (a) colloidal gold, (b) the B-gal reporter, (c) alkaline phosphatase, or (d) luciferase were compared. Colloidal gold-labeled probes did not penetrate tissue and were not suitable for quantitative in situ detection. None of the methods tested using fixed tissue gave results that approached the sensitivity and resolving ability of techniques employing radioactive probes. However, both alkaline phosphatase and luciferase-based technologies show promise as potential reporters of gene expression in living cells."

B.23 Task 0023. Support of Visual Spatial Orientation Display Development

B.23.1 Objective

KRUG Life Sciences, Incorporated, was tasked to conceive, generate, and psychophysically analyze candidate visual displays that will be evaluated for possible use in aircraft. In addition, KRUG Life Sciences, Incorporated, was to provide scientific expertise in support of inflight head-up display (HUD) and head-down display (HDD) research conducted in coordination with the USAFSAM and the USAF IFC.

B.23.2 Accomplishments

The results of this effort are described in the following reports and publications.

Previc F, Weinstein L, Breitmeyer B. Visual attention and perception in three-dimensional space. AL-TR-1991-0119. 1992:22pp.

Abstract: "The effects of shifting attention to targets in 3-dimensional (3-D) visual space were investigated. The perceptibility of crossed-disparity (near) and uncrossed-disparity (far) targets located in the upper-left, upper-right, lower-left, and lower-right visual quadrants was measured during attention shifts that were directed by means of centrally presented arrows to the left or right, upper or lower, and near or far fields. Although left-right attention cues produced the expected perceptibility benefits, upper-lower cues produced no benefits and near-far ones produced attentional costs. The effect of shifting attention along the up-down axis using peripheral cues was also investigated; in this case, significant benefits were obtained, especially in the upper visual field. These results and those from basic detectability experiments point to the existence of important inhomogeneities in perceiving and attending to targets in 3-D visual space."

Simpson C, Lyons T, Weinstein L, Previc F, Gillingham K. The effect of thumb and index finger control in overcoming a visual analogue of the giant hand illusion. (Abstract) Aviat. Space Environ. Med. 1991;62:495.

Abstract: "INTRODUCTION. Anecdotal evidence suggests that a thumb and index finger grip might facilitate recovery from the giant hand phenomenon, a manifestation of spatial disorientation in flight. METHODS. Sixteen pilot volunteers used an F-16 side-arm force-stick controller to perform a roll-tracking task in a visual flight simulator with a 115x105-degree field of view. The subjects attempted to maintain an unstable attitude display at perceived wings-level orientation under two different conditions; (1) the background scene moving (rolling) with the attitude display (congruent) and (2) the scene rotating independently of the display (incongruent). The incongruent scene condition was sufficiently disorienting to create a semblance of the giant hand phenomenon. Control accuracy was tested alternately with a whole hand grip and the thumb and index finger grip. RESULTS. The incongruent visual scene produced a powerful bias in all subjects' tracking behavior, ranging from 8 to 25 degrees. Thumb and index finger control produced greater stability, but there was no significant difference in the mean roll tracking bias for the two types of grip. CONCLUSIONS. The thumb and index finger technique was ineffective in overcoming the visually-induced motor bias that resembles the giant hand phenomenon. Various hypotheses to explain this result are discussed. Further research is needed to determine the nature of the giant hand phenomenon and to demonstrate effective countermeasures.

Weinstein L, Ercoline W. HUD climb/dive ladder configuration and unusual attitude recovery. Proceedings 35th Annual Mtg of the Human Factors Society. San Francisco, CA, Human Factors Society. 1991:12-6.

Abstract: "Twelve head-up display (HUD) experienced pilots participated in a study that examined the effects of articulated lines versus parallel, tapered lines in the top and bottom halves of the climb/dive ladder for recovering from nose-down unusual attitudes in a flight simulator. These configurations were assessed using a moving climb/dive marker (CDM) on half of the trials and a fixed pitch reference for the remaining trials. The results indicated that the climb/dive ladder configuration did not affect a pilot's reaction time to initiate a recovery. However in terms of accuracy of the initial, significant stick input, the articulated lines in the bottom half of the HUD with a moving CDM resulted in significantly poor performance (about 12% worse) than that associated with the other three configurations. Subjective data suggest that pilots preferred the articulated lines in the bottom half of the HUD even though their preferences did not correlate with their performance. These findings suggest that articulated lines in the bottom half of the HUD are detrimental to a pilot's ability to recover from nose-down unusual attitudes."

Weinstein L, Ercoline W. The standardization of military head-up display symbology. In: R. Jensen (Ed.), Proceedings of the Sixth International Symposium on Aviation Psychology, Columbus, OH. 1991:210-5.

Abstract: "Although initially intended for the presentation of landing and weapons delivery information, the HUD has evolved into a flight instrument that researchers and pilots claim is successfully replacing many of the traditional panel instruments. Since the Attitude Awareness Workshop of 1985, the United States Air Force (USAF) has conducted numerous research projects to determine the most effective way to integrate the HUD with the other mission-essential instrument displays. The requirement to use the HUD for instrument flight, as well as a need to determine the optimal layout for the HUD symbols, has prompted a significant portion of that research. This paper summarizes many of the research efforts conducted, conclusions reached, and issues yet to be resolved. In addition, the paper outlines the current USAF position for using the HUD. Suggested standardization guidelines based on empirical findings are discussed, including: the use of vertical and horizontal asymmetry for pitch-ladder configurations, quickening, and counter-pointers for airspeed and altitude indicators. Current research efforts that will be completed in the coming year are also described. These efforts include simulator studies and inflight validation."

Weinstein L, Previc F, Simpson C, Lyons T, Gillingham K. A test of thumb and index finger control in overcoming a visual analogue of the giant hand illusion. *Aviat. Space Environ. Med.* 1991;62:336-41.

Abstract: "Anecdotal evidence suggests that a thumb and index finger grip might facilitate recovery from the manifestation of spatial disorientation known as the giant hand phenomenon. Sixteen pilots volunteered as subjects in an experiment that compared the effectiveness of the thumb and index finger versus the whole hand technique to overcome a visually-induced analogue of the giant hand phenomenon. Thumb and index finger control produced greater stability overall, but did not overcome the specific tracking bias induced by a background visual roll stimulus. Various hypotheses are discussed as to why the thumb and index finger technique was ineffective in the present instance."

B.24 Task 0024. Acquisition of Physiological Data During G-LOC

B.24.1 Objective

KRUG Life Sciences, Incorporated, was tasked to develop a data acquisition system for the SAC and the TCD and perform required research into the hemodynamic/biochemical alterations during G-LOC. This task shall include the daily operation and maintenance of the SAC and Waters HPLC units.

B.24.2 Accomplishments

Technical support was provided for data acquisition resulting in the following papers.

Shahed AR, Werchan PM. Cerebral biochemical basis of +Gz induced loss of consciousness (G-LOC). (Abstract) *Aviat. Space Environ. Med.* 1992;63:424.

Werchan PM, Dietz NJ, Waller SB, Shahed AR. Deceleration associated loss of consciousness: a new component of G-LOC? (Abstract) *Aviat. Space Environ. Med.* 1991;62:477.

Werchan PM, Shahed AR. Investigations of G-induced loss of consciousness (G-LOC) using the rodent centrifuge model. (Abstract) Aviat. Space Environ. Med. 1992;63:424.

Other results of this effort are described in the following reports.

Barber JA, Shahed AR, Werchan PM. Rat brain edema after multiple +Gz exposures. (Abstract) Aviat. Space Environ. Med. 1992;63:425.

Abstract: "INTRODUCTION. Phenomena of acceleration or +Gz induced loss of consciousness (G-LOC) is known to occur in pilots of high performance aircraft and has been reproduced in animal models in the laboratory. It has been demonstrated that during +Gz exposure cerebral blood flow is significantly reduced resulting in brain ischemia. This situation could be repeated several times by pilots during flight maneuvers. Unfortunately, we know little about pathological effects on the brain. One of the earliest pathologic changes of ischemic stress is brain edema. In the present study occurrence of brain edema in the rat after +Gz exposure was investigated. METHODS. Male rats (n=4) were exposed to 6, +25 Gz runs with 5 min rest period[s] between each run. Brains were removed 15 min, 30 min, 3 hr, and 24 hrs (n=5 in each group), after the last centrifuge run, and weighed (wet weight) and then oven dried to constant dry weight. The ratio of wet to dry weight was used to assess % change in brain's water content (edema). RESULTS. The data show that % of water in brain tissue increased significantly up to 3 hr after the centrifuge run, but not after 24 hr. The largest increase in water (2%) was observed at 15 min. CONCLUSION. These results show that multiple +Gz exposure[s] can cause brain edema. Edema can result in post +Gz exposures hypoperfusion and could cause secondary ischemia thus exacerbating the functional effects related to G-LOC."

Desmond JL, Werchan PM. Transcranial Doppler stabilization during acceleration and maximal exercise tests. 29th Annual SAFE Symposium Proceedings. 1991:272-3.

Abstract: "The transcranial Doppler (TCD) is used as a non-invasive technique to measure cerebral blood flow (CBF) velocity. It has been applied to the clinical and diagnostic settings, although the measurement could be useful in aerospace physiology research as well. Initial use of TCD during acceleration stress and maximal-effort cycling exercise revealed that the commercially available probe assembly did not provide: 1) adequate stabilization of the TCD probe to prevent movement during centrifugation and maximal exercise, 2) ease of focusing on middle cerebral artery (MCA) and, 3) [a] secure locking mechanism to prevent probe dislocation during head movement. Because of the above difficulties, a functional TCD probe, probe support, and headgear assembly was designed and fabricated. The criteria consisted of the following: 1) subject comfort, 2) focusing ability, 3) signal maintenance and 4) compatibility with other monitoring devices used during acceleration and exercise related research. This paper will discuss fabrication, instrumentation techniques, and stabilization methods for transcranial Doppler use in aerospace physiologic research at the Armstrong Laboratory, Brooks AFB, TX."

Galindo S Jr, Werchan PM, Shahed AR. Estimation of cerebral blood flow volume in rats during +Gz stress. (Abstract) Aviat. Space Environ. Med. 1992;63:424.

Abstract: "INTRODUCTION. +Gz induced loss of consciousness (G-LOC) has been proposed to result from a critical reduction of cerebral blood flow (CBF) during high +Gz stress. However, an accurate measurement of CBF during +Gz has been difficult to accomplish. Methods such as transcranial Doppler and radiolabelled microspheres have been used in humans and primates to measure CBF, but neither method estimates residual blood in the brain during +Gz stress. In the present study, 3 other methods to estimate CBF in rats and mice were used. METHODS. Rats were exposed to a single +25 Gz [acceleration] and brain samples were collected by freeze fixation at desired times. Mice, similarly were exposed to +15 to 35 Gz for 30 s and brains were fixed by microwave. Brain tissue homogenates were analyzed for total protein, hemoglobin (Hb) and iron (Fe). RESULTS. Total protein (25%) and Hb (38%) content decreased maximally 15 s after onset of +25 Gz in rats. Total FE content showed a similar decrease. Total protein concentration in mice brain decreased at +20 Gz and higher. Hb and Fe content in mice brain tissue are being investigated. CONCLUSION. The decreases in total protein and Hb are indicators of a decrease in total blood flow to the brain. But the presence of Hb suggests that trapped blood remains in the brain. We believe that this residual blood acts as an energy pool that could delay the onset of G-LOC in a high +Gz environment that follows a decrease in carotid artery blood pressure."

Garcia SK, Garza JR, Coffey DJ, Werchan PM. Use of EEG spectral analysis to identify G-induced loss of consciousness (G-LOC) in the rat. (Abstract) Aviat. Space Environ. Med. 1992;63:425.

Abstract: "INTRODUCTION. Despite numerous technological advances to improve G-tolerance, loss of consciousness due to +Gz stress continues to be a problem with fighter pilots. In recent years, research has focused on the use of EEG relating G-LOC with cerebral activity. It has been shown that with G-LOC, EEG amplitude decreases and can become isoelectric. However, the isoelectric point may occur beyond useful consciousness. Thus changes in EEG frequency components during this period may be a more sensitive indicator of the level of consciousness. METHODS. Male rats (250-350g), with surgically implanted bipolar parietal electrodes, were exposed to +25 Gz in a small animal centrifuge until loss of EEG amplitude (G-LOC). EEG recordings were obtained for each rat and subjected to EEG spectral analysis. RESULTS. Preliminary results suggest that during baseline and onset of acceleration EEG activity consisted of all component frequencies from 0-30 Hz. Early in the G exposure there was a significant shift towards the delta frequency band (0-4 Hz). At the point of isoelectric EEG, delta frequency disappeared along with other frequencies. Early recovery following G exposure was again marked by a pronounced increase in delta activity. CONCLUSION. Spectral analysis of EEG provides a more objective/sensitive approach to G-LOC detection by identifying changes in component frequencies."

Shahed AR, Stavinocha BB, Barber JA, Werchan PM. The use of microwave (MW) fixation for the determination of mouse brain

metabolites during high +Gz (head-to-foot) exposure in a small animal centrifuge (SAC). (Abstract) Soc. Neurosci. Abstr. 1991;17:1262.

Abstract: "The mechanism or effects of acceleration induced loss of consciousness (G-LOC) observed in pilots of high performance aircraft are not fully understood. It has been proposed that cerebral blood flow may cease due to zero carotid artery pressure within 2s after >5 +Gz exposure. **HYPOTHESIS:** G-LOC may result from global ischemia and subsequent energy depletion. **METHODS:** A SAC equipped with a 2450 MHz, 10 KW, MW system with rotating waveguide was used for brain fixation. Mice were exposed to either varying +Gz (15 to 35) forces or duration (0-35s) and brains were fixed at specific time points during and 60s post run. Brain glycolytic and high energy phosphates were measured. **RESULTS:** The G-tolerance data show that the levels of glucose, C-P and ATP decreased and lactate accumulated as +Gz force increased. The time curve shows significant changes in glucose (-85%), C-P (-73%) and ATP (-22 %), lactate (+220%), AMP (+67%) and adenosine (+10 fold) 35s after the onset of 35 +Gz. The level of these metabolites were not restored 60s after the SAC run. **CONCLUSIONS:** (1) MW is an ideal tool for brain fixation during +Gz exposure. (2) G-LOC may occur to conserve energy resources during the cessation of cerebral blood flow in a high +Gz environment."

Werchan PM, Garcia SK, Shahed AR, Barber JA, Coffey DJ, Desmond JL, Galindo S Jr, Garza JR. Acquisition of physiological data during G-induced loss of consciousness (G-LOC). AL-TP-1992-0053. 1993:12pp.

Abstract: "The objective of this study was to develop a data acquisition system for the small animal centrifuge (SAC) and the transcranial Doppler (TCD) and to perform required research into the hemodynamic/biochemical alterations during G-induced loss of consciousness (G-LOC). This effort was to include the daily operation and maintenance of the SAC and Waters High Performance Liquid Chromatography units. The original data were turned over to the Flight Motion Effects Branch. The results of this effort were published as the article and abstracts included in this technical paper."

B.26 Task 0026. NASA Anti-G Suit Design, Development, and Fabrication

B.26.1 Objective

KRUG Life Sciences, Incorporated, was tasked to: (a) Determine whether an extended coverage anti-G suit to be developed by KRUG Life Sciences, Incorporated, offers better protection than the standard CSU-13B/P anti-G suit in preventing the symptoms of post-shuttle flight orthostatic intolerance; (b) Determine the relative comfort and mobility offered by the two suit concepts; (c) Determine the degree of +Gz protection provided with and without an inflated abdominal bladder during simulated shuttle reentry profiles; (d) Determine when the suit should be inflated, i.e., before or after onset of symptoms; (e) Determine the optimal inflation pressure of the selected suit; (f) Design, develop and fabricate two anti-G suits for evaluation purposes and two suits for use in space flight testing which meet all applicable NASA flight requirements.

B.26.2 Accomplishments

Four suits were delivered. Extensive modifications of the two suits originally planned to meet NASA flight requirements obviated their use in flight as agreed by NASA and KRUG Life Sciences, Incorporated. The results of this effort have been incorporated in the following publications.

Krutz RW, Stegmann BJ, Burton RR, Sawin CF. An evaluation of three anti-G suit concepts for shuttle reentry. 29th Annual SAFE Symposium Proceedings. 1991:24-6.

Abstract: "Crewmembers during reentry from space flight are experiencing discomfort from the anti-G garment installed in the current launch-entry suit (LES). For this and other reasons, NASA is developing a new LES with an improved anti-G suit (both protection and comfort) as an integral yet separable component. With the above criteria in mind, this study was conducted to compare the standard LES anti-G suit with a reentry full-coverage anti-G suit (REAGS) and a REAGS without an abdominal bladder (AB). (The inflated AB is the most uncomfortable G-suit component.) Intravenous Lasix, a diuretic, was used to induce the fluid loss seen during space flight. Using the Armstrong Laboratory Centrifuge, data collected from seven subjects have shown that less anti-G suit pressure is required to maintain eye-level systolic blood pressure above 70 mmHg when the REAGS or REAGS without AB is worn during simulated shuttle reentry G-profiles when compared to the current LES G-suit. The REAGS without AB was significantly more comfortable than the standard anti-G suit."

Krutz RW Jr, Stegmann BJ, Burton RR, Sawin CF. Effect of preacceleration inflation or tolerance to simulated Space Shuttle re-entry G profiles in dehydrated subjects. AL-TP-1992-0022. 1993 [In Preparation].

Abstract: "The study reported in this technical paper examined the benefits (if any) of inflation of a standard 5-bladder anti-G suit 10 minutes prior to a simulated space shuttle G reentry using Lasix-dehydrated subjects. The drug was intravenously administered approximately 6h prior to exposure to the simulated reentry acceleration profile using the Armstrong Laboratory Centrifuge. The subjects underwent two separate G exposures. During one exposure, the suit was inflated over a period of one minute to 1.5 psig beginning 10 minutes prior to acceleration onset (preinflation). During the second exposure the suit was not preinflated but was pressurized in 0.5 psig increments if the peripheral (green) lights on the centrifuge light bar dimmed to 50% of their original intensity (PLD; symptomatic inflation). Eye-level systolic blood pressure (ELBP) was monitored by a non-invasive technique (FinapresTM) which is based on blood volume changes in a segment of a finger supported at heart level. A water column was used to correct readings for ELBP. Heart rate (HR) was obtained from a two-lead ECG and cardiometer. Results showed that slow (60s) preinflation of the standard 5-bladder anti-G suit to 1.5 psig beginning 10 minutes prior to acceleration onset tends to maintain ELBP at a higher level and maintains maximum HR at a lower level during exposure to simulated space shuttle reentry G-levels when compared to symptomatic (PLD) inflation."

Stegmann BJ, Krutz RW, Burton RR, Swain CF. Comparisons of three anti-G suit configurations during long duration, low onset, +Gz. (Abstract) Aviat. Space Environ. Med. 1992;63:420.

Abstract: INTRODUCTION: Little physiologic data exist on the effects of long duration, low onset, +Gz. Space shuttle crewmembers are subjected to low +Gz forces (less than +3 Gz) for upwards of 30 minutes during reentry. A similar reentry profile is predicted for the National Aerospace Plane (NASP). The physiologic effects of this acceleration stress are compounded by the loss of body water experienced during microgravity. Currently, [a] standard 5 bladder anti-G suit is being used during shuttle reentry. There have been complaints of discomfort using this suit, mainly due to the abdominal bladder. This study compared the effectiveness of three anti-G suit configurations in volume-depleted subjects during a simulated space shuttle reentry profile. METHODS: Seven male subjects were given intravenous Lasix in a dose from 20-40 mg to induce a total body weight loss of 3+/- 1.5%. Approximately six hours after the injection, the subjects donned one of three anti-G suits--a standard 5 bladder anti-G suit, an extended coverage anti-G suit (the Advanced Technology Anti-G suit or ATAGS), or an extended coverage anti-G suit without an abdominal bladder (the reentry anti-G suit or REAGS). All subjects were exposed to a simulated space shuttle reentry profile. Non-invasive eye-level blood pressure (ELBP) was monitored throughout the +Gz exposure. When systolic ELBP dropped below 70 mmHg, the anti-G suit was inflated in 0.5 psig increments to the pressure required to maintain 70 mmHg ELBP. Each subject rode with all three suits. Comparisons were made between the final pressure required in each suit to maintain ELBP and subjective reports of comfort. RESULTS: The mean final suit pressure required to maintain ELBP was 1.1 psi in both the ATAGS and REAGS vs. 1.8 psi in the standard suit. In addition, the subjects rated the REAGS suit highest on the comfort scale, citing the absence of the abdominal bladder as the main reason. CONCLUSIONS: Overall, the REAGS suit was the superior anti-G suit during long duration, low onset +Gz. This is based on its ability to maintain ELBP and still remain comfortable when inflated for prolonged periods of time."

Stegmann BJ, Krutz RW Jr, Burton RR, Sawin CF. An evaluation of the lower coverage anti-G suit without an abdominal bladder after three days of seven-degree head down tilt. IAF/IAA-92-0264. 43rd Congress of the International Astronautical Federation. 1992:4pp.

Abstract: "During space shuttle reentry, volume-depleted astronauts experience slow onset, long duration, low level +Gz. In Phase 2, we determined that an extended coverage anti-G suit without an abdominal bladder (Reentry Anti-G Suit: REAGS) was the most effective anti-G suit in subjects dehydrated with furosemide (Lasix). The present study (Phase 3) verified that REAGS provided effective protection for subjects dehydrated with 7 degrees head down tilt (HDT). Twelve healthy male subjects were placed at 7 degrees HDT for 3 days, and then subjected to an acceleration profile simulating shuttle reentry while wearing the REAGS suit. Six subjects had their anti-G suit inflated when their eye level blood pressure (ELBP) fell below 60 mmHg, while six

subjects had their suit inflated when they experienced peripheral light dim (PLD). Average REAGS pressure required to maintain ELBP at or above 60 mmHg after HDT was 0.85 psig vs 1.0 psig in subjects dehydrated with Lasix. One subject in the PLD group experienced G-LOC; however, this may have been related to the greater cardiovascular stress induced by HDT."

B.28 Task 0028. Aerospace Cardiovascular Research

B.28.1 Objective

KRUG Life Sciences, Incorporated, was tasked to provide, test, and evaluate a custom-designed noninvasive blood pressure measuring device.

B.28.2 Accomplishments

A BMI-TNO Portapres with built-in TEAC recorder was purchased, tested, and delivered. The four gloves constructed for use with the pressure cuff were delivered and performed satisfactorily. Test results, filed with the unit, include information about limitations regarding use of automatic calibration during acceleration and subject hand position and motion during acceleration.

B.30 Task 0030. Spatial Disorientation; Visual Flight Simulation

B.30.1 Objective

KRUG Life Sciences, Incorporated, was tasked to provide computer systems analysis and software development needed to implement flight simulation and instrument displays for research efforts in spatial disorientation causes and countermeasures.

B.30.2 Accomplishments

Programming, systems analysis, and documentation support was provided for development of visual flight simulation software. A user's guide and programmer's guide for the flight simulator program and programmer's guide for the "energy" program developed under this task were submitted to the Flight Motion Effects Branch.

B.31 Task 0031. Support for Development of Visual and Auditory Displays of Spatial Orientation Information

B.31.1 Objective

KRUG Life Sciences, Incorporated, was tasked to conceive, generate, and scientifically evaluate visual and auditory display symbologies for possible use in aircraft.

B.31.2 Accomplishments

The results of this effort are described in the following reports.

Teas DC. A special-purpose virtual audiometer. AL-TR-1992-0124. 1993:34pp.

Abstract: "A Virtual Audiometer is described. The audiometer is designed so that the users can measure their own thresholds and binaural loudness balances in a moderately noisy environment for a range of frequencies from 250 to 6000 Hz. Operator supervision required is minimal. The

audiometer is constructed with a computer-assisted software engineering base called LabVIEW. Several users-aids are available from the virtual Front Panel of the instrument that contribute to the accuracy of the subject's determinations. The organization of the virtual instrument is illustrated and discussed. Sample data from four subjects of contrasting ages are included."

Teas DC. A virtual acoustic orientation instrument. AL-TR-1992-0157. 1993:50pp.

Abstract: "Virtual instrumentation developed to create acoustic stimuli for use as orientation signals and the rationale for selecting these target signals are described. A commercially available computer-assisted software engineered programming system, LabVIEW, was used to develop the acoustic signals and the manner of their presentation. Two different acoustic signals are presented. One sound seems to change pitch without limit, and the other is a narrow band-pass noise. The pitch, loudness and lateral position of the signals are controlled by different functions. Listeners can control the variations in pitch and lateralization and also the rate at which these features change. Programs to generate the signals with sinusoids or with noise bands are described. LabVIEW representations of the programs are included with text descriptions."

Weinstein LF, Ercoline WR. The standardization of USAF head-up display symbology. 30th Annual SAFE Symposium Proceedings. 1992:106-8.

Summary: Researchers and pilots throughout the world continue to examine and debate the utility of the head-up display (HUD) for presenting instrument flight information. Although initially intended for the presentation of landing and weapons delivery information, the HUD has evolved into a flight instrument that researchers and pilots claim is successfully replacing many of the traditional panel instruments. Since the Attitude Awareness Workshop of 1985, the United States Air Force (USAF) has conducted numerous research projects to determine the most effective way to integrate the HUD with the other mission-essential instrument displays. The requirement to standardize the HUD symbology for instrument flight, as well as a need to determine the optimal layout for the HUD symbols, has prompted a significant portion of that research. This presentation summarizes many of the research efforts conducted, conclusions reached, and issues yet to be resolved including the use of: vertical and horizontal asymmetry for pitch-ladder configurations, counter-pointers for airspeed and altitude indicators, acceleration and angle-of-attack cues for energy management, and quickening for flight-path markers. The results of an inflight validation of the proposed HUD standard indicate that it is safe and useable in fighter class aircraft during instrument meteorological conditions.

Weinstein LF, Ercoline WR. The standardization of head-up display symbology for the reduction of spatial disorientation. (Abstract). Aviat. Space Environ. Med. 1992;63:443.

Abstract: "**INTRODUCTION.** Researchers and pilots continue to debate the utility of the head-up display (HUD) for presenting adequate and easily assimilable control and

performance information for use during instrument weather conditions. The HUD has evolved into a flight instrument that is being used to replace many of the traditional panel instruments. **METHOD.** Since the Attitude Awareness Workshop of 1985 the United States Air Force (USAF) has conducted numerous research projects to determine the optimal configuration for the HUD symbology set to increase spatial orientation and reduce mental workload during instrument flight. Many of the research efforts conducted, conclusions reached and issues yet to be determined are addressed. **RESULTS.** Suggested standardization guidelines based on empirical findings are discussed, including: counterpointers for airspeed and altitude, integration of altitude and vertical velocity information, vertical and horizontal asymmetry for the climb/dive ladder, and the utility of articulated climb/dive bars. **CONCLUSIONS.** A standard symbology set, based on the findings from these and other laboratories' studies, has been proposed for use during instrument flight conditions. The inflight validation of this proposed standard has been completed. The standard is scheduled to be included in MIL STD 1787, Aircraft Display Symbology."

Weinstein L, Ercoline W, Evans R. The utility of analog vertical velocity information during instrument flight with a head-up display (HUD). AL-TP-1992-0021. 1992:26pp.

Abstract: "The United States Air Force (USAF) is attempting to create a standard symbol set for use with the HUD as a primary flight reference. As part of that effort, eight HUD-experienced pilots and twelve non-HUD-experienced pilots participated in a study that examined the effects of variations in vertical velocity indicators (VVI) for use under instrument flight conditions in a simulator. Five configurations were assessed: digital readout, boxed digits with tape, dial, altimeter arc, and altimeter arc with digital readout. The results clearly indicated that the altimeter arc with digital readout, and the altimeter arc alone, resulted in significantly more accurate maintenance of flight parameters (i.e., vertical velocity and altitude) than did the digital readout alone, the boxed digits with tape, or the dial. Subjective data supported the objective findings, in that pilots preferred either configuration that included the altimeter arc. These findings suggest that analog vertical velocity information is useful on the HUD, particularly when it is located in proximity to the altimeter."

B.32 Task 0032, IPE Mission Ergonomics and Stress

B.32.1 Objective

KRUG Life Sciences, Incorporated, was tasked to evaluate optimal effects of work/rest cycles, breathing resistance, protective ensemble near-term options, and personal air blowers on human performance. Experimental approaches were to include both in vivo human or applied physiological model along with computer modeling.

B.32.2 Accomplishments

The results of this effort are described in the following technical report.

Antunano MJ, Baumgardner FW, Chen YT, Constable SH. Physiological responses to varying workloads and configurations of the MCU-2/P chemical defense mask. AL-TP-1992-0042. 1993:42pp.

Abstract: "An objective of this study was to evaluate the breathing resistance characteristics of MCU-2/P and M-17 chemical defense masks during individual exposures to 8 consecutive incremental workloads. Other objectives included: evaluation of cardiorespiratory and subjective responses and testing of two commercially available blowers. Five MCU-2/P mask configurations were tested: mask without filter (MCU-OF), mask + 1 filter (MCU-1F), mask + 2 filters (MCU-2F), mask + 1 filter + blower A (MCU-1F-AABA), and mask + blower B + 2 filters (MCU-ABB-2F). An M-17 mask was also tested. Each subject walked on a treadmill for 5 min at each of 8 consecutive incremental workloads (ranging from 26 to 77% of VO_{2max}) for a total of 40 min, while wearing each mask configuration. Variables measured included inspiratory and expiratory mask cavity pressures (IMCP & EMCP), mask cavity pressure-swing (MCPS), peak inspiratory airflow (PIAF), respiratory rate (RR), tidal volume (VT), minute volume (VE), heart rate (HR), perceived inspiratory & expiratory effort (PIE & PEE), and overall breathing discomfort (OBD). The MCU-1F and M-17 masks imposed the same magnitudes of inspiratory resistance at any given workload. The highest inspiratory resistance was imposed by the MCU-1F and M-17 masks, while the lowest corresponded to the MCU-ABB-2F and MCU-2F. Either of these two masks can be expected to decrease individual tolerance to sustained physical work. The MCU-ABB-2F and the MCU-2F were the most effective methods to reduce the magnitude of inspiratory resistance at any given workload."

B.34 Task 0034, Improved ATAGS Anti-G Suits for Flight Test

B.34.1 Objective

KRUG Life Sciences, Incorporated, was tasked to construct eight (8) improved ATAGS anti-G suits suitable for flight testing.

B.34.2 Accomplishments

Eight improved ATAGS and patterns were delivered to the Air Force. Pressure tests were accomplished on all eight of the delivered suits and they were successfully tested during an early operational demonstration.

B.35 Task 0035, Acquisition of Physiological Data During G-LOC; Phase II

B.35.1 Objective

KRUG Life Sciences, Incorporated, was tasked to continue the work in the areas of blood flow and other physiological parameters related to G-LOC in both humans and rodents.

B.35.2 Accomplishments

Software was designed, developed, and implemented to create a SAC Data Acquisition System. The Integrated Acquisition, Storage, Display, Analysis, and Data Transport System software was designed to measure and record the electrical impulses generated by the CFT Small Animal Centrifuge System. The software was created within the National Instruments LabVIEW Graphical Programming Environment and makes extensive use of the

languages optimized C-Language routines to perform its tasks. The system has four areas of operation: 1) Data Acquisition, configuration for a wide range of Sample speeds, number of channels, individual channel gains, etc.; 2) Data Retrieval & Display, accessing, scaling, and display of desired data files; 3) EEG Frequency Analysis, routines which produce both standard X-Y Power Spectrum displays as well as 3-Dimensional EEG surface contour plots; 4) Utilities & Data Transport, routines to create ASCII files of large, unscaled, binary data files created by the acquisition program for export to other CFT processing platforms.

The results of this effort are described in the following report.

Shahed AR, Galindo S Jr, Barber JA, Werchan PM. Mice brain regional metabolites and blood volumes (BV) after 30 sec of global ischemia in a small animal centrifuge (SAC). (Abstract) Soc. Neurosci. Abstr. 1992;18:1582.

Abstract: "Recently we have used a SAC to study the effect of high +Gz (head-to-foot) exposure on cerebral metabolism and to understand the mechanism of gravity induced loss of consciousness (G-LOC). G-LOC has been proposed to result from a critical reduction in cerebral blood flow (CBF) during +Gz exposure. We have shown that a 30 sec +35Gz exposure caused G-LOC and global ischemia in mice. (Soc. Neurosci. Abstr., Vol. 17(2):1262, 1991). We proposed that G-LOC may occur to conserve energy and minimize acidosis during +Gz exposure. Measurement of CBF in the dynamic environment of SAC is difficult. The brain is heterogeneous in structure, function and CBF. Therefore the objective of the present study was to measure BV and regional energy metabolism during +Gz stress. **Methods:** Fully awake mice were exposed to +35Gz for 30 sec in the SAC (to induce global ischemia) and brain sampled at various time points during and after deceleration by microwave fixation. The brain was dissected in 5 regions and tissue extracts were analyzed for metabolites and total iron to determine the BV. Control mice were exposed to 0.5 Gz for 30 sec and the brain sampled. **Results:** Data show that the level of lactate increased and glucose, Cr-P and ATP decreased significantly in all regions after 30 sec except the cerebellum (CB). The level of metabolites did not return to control levels 60 sec after deceleration. BV decreased more than 50% in all regions except the mid brain (25%) and CB (no change). There was a pronounced hyperemic response in the hippocampus, brain stem and mid brain 30 sec after deceleration. **Discussion:** It is concluded that high +Gz exposure effects regional metabolism uniformly. The presence of BV, although reduced, indicated trapped blood in the brain circulation. We propose that during +Gz exposure trapped blood may prolong the onset of G-LOC after CBF ceases."

B.36 Task 0036. Neuropharmacology of Light-Induced Gene Expression in the Suprachiasmatic Nucleus: Phase II

B.36.1 Objective

KRUG Life Sciences, Incorporated, was tasked to research the neurochemical basis of specific genetic expression in the SCN of intact hamsters and rat brain hypothalamic slices in response to

either retinal illumination or optic nerve stimulation. Emphasis on specific effects involving (1) excitatory amino acid agonists and antagonists, (2) GABA agonists and antagonists, and (3) cyclic nucleotide, phosphoinositide, and arachidonic acid derived second messengers will be made concerning the stimulated expression of the c-fos proto-oncogene using both the in vivo and in vitro models. Additionally, experimental research will be conducted to assess the biochemical nature of insensitivity during daytime periods of light stimulation on the circadian pacemaker.

B.36.2 Accomplishments

Software was designed, developed, and implemented to create a Suprachiasmatic Nucleus (SCN) Data Acquisition System. The Integrated Acquisition, Storage, Display, Analysis, and Data Transport System software was designed to measure and record the electrical impulses generated by the SCN Data Acquisition System. This software will measure and record the electrical impulses generated by the CFT Neurosciences Electro-Physiology Specimen Preparation System. The software was created within the National Instruments LabVIEW Ver. 2.2.1 Graphical Programming Environment and makes extensive use of the optimized C-Language routines to perform its tasks. The system has four areas of operation: 1) Environment Configuration, A/D card configuration and configuration of the RAM locations where data is stored; 2) Acquisition, sampling and storage of data in memory; 3) Data Display and Interaction, plotting of the parameters on an X-Y plot with signal amplitude (Volts) on the vertical axis and time (seconds) on the horizontal; 4) Utilities & Data Transport, routines to create ASCII files of large, unscaled, binary data files created by the acquisition program for export to other CFT processing platforms.

Technical support was provided for data acquisition resulting in the following papers.

Glass JD, Hauser UE, Randolph WW, Rea MA, and De Vries MJ. In vivo microdialysis of 5-hydroxyindoleacetic acid and glutamic acid in the hamster suprachiasmatic nuclei. Am. J. Zool. 1993 [In Press].

Glass JD, Randolph WW, Ferreira SA, Rea MA, Hauser UE, Blank JL, De Vries JD. Diurnal variation in 5-hydroxyindoleacetic acid output in the suprachiasmatic region of the Siberian hamster assessed by in vivo microdialysis: Evidence for nocturnal activation of serotonin release. Neuroendocrinology. 1992;56:582-90.

Rea MA. Light, gene expression and entrainment of circadian rhythms. Photochem. Photobiol. 1992;55:20S.

Rea MA, Michel AM, Lutton LM. Effects of local administration of excitatory amino acid agonists on circadian phase and c-fos expression in the hamster SCN. (Abstract) Soc. Neurosci. Abs. 1992;18:3.

Other results of this effort are described in the following report.

Senseman DM, Hart K, Solis J, Gonzalez G, and Rea MA. Functional organization of the hamster SCN visualized with

voltage-sensitive dyes. (Abstract) . Soc. Neurosci. Abs. 1992;18:878.

Abstract: "How afferent input from the retinohypothalamic tract (RHT) can phase shift the circadian oscillator is still largely unknown. Spatial differences in SCN field potentials have been observed in response to optic nerve stimulation (Shibata et al., Brain Res. 12:377, 1984) suggesting a possible functional organization to the SCN's intrinsic neural circuitry that might be related to the entrainment process. To investigate this possibility, we are using multiple-site optical recording techniques (Obaid et al., Neurosci. Abstr. 16: 1185, 1990) to visualize and map spatiotemporal differences in neuronal activity in the hamster SCN. The figure below shows three (of 124) optical traces recorded from a 400 μ m horizontal slice stained with the dye RH155 following electrical stimulation of the optic nerve. These traces were recorded from adjacent 120x120 μ m regions of the SCN and illustrate the degree of spatiotemporal variation observed. Supported by: RDL 18, GM 08194, GM07717 & AFOSR 2312W6."

B.37 Task 0037. Additional Improved ATAGS Anti-G Suits for Flight Test

B.37.1 Objective

KRUG Life Sciences, Incorporated, was tasked to construct twelve improved Advanced Technology Anti-G Suits (ATAGS) suitable for flight testing.

B.37.2 Accomplishments

Twelve improved ATAGS were pressure tested, delivered, and used for flow and filling-time evaluations.

The following publication describes the results of technical and scientific research support of ATAGS RDT&E.

Meeker LJ, Olhausen JH, Ripley GL. System parameters of the advanced technology anti-G suit (ATAGS). A progress report. 30th Annual SAFE Symposium Proceedings. 1993:345-50.

Abstract: "Previous centrifuge and flight testing have shown that the ATAGS offers superior G endurance protection even when operated at lower pressures than the standard anti-G suit. All of the previous ATAGS testing was done, however, using human test subjects for the purpose of evaluating G protection. The purpose of the parametric tests was to provide basic system data such as volumes, fill rates, and pressure differentials for the ATAGS. In order to allow direct comparison with data taken previously on the AF standard anti-G suit (CSU-13A/P), these tests were based on procedures detailed in SAM-TR-78-12, Engineering Test and Evaluation During High G, VOL III: Anti-G Suits. ATAGS volumes were measured using pressure change during expansion from a known volume. The volumes of several suit sizes were taken, both with the suit unmounted and mounted on a mannequin to a proper fit. Total flow was measured with a flowmeter in the main fill hose. Differential pressure in various parts of the suit during rapid fill was measured at test points located on both sides of the abdominal bladder, on each thigh, and at the bottom of each leg. Preliminary data from these tests are presented."

PART C:

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PART D:

AUTHOR CROSS-REFERENCE

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