The +$G_z$ette

Submissions from the International Acceleration Research Workshop Community

Volume 2, Issue 1 May 2002

INSIDE THIS ISSUE

Where and When

This is the 15th anniversary of the International Acceleration Research Workshop conceived by Dr. Russell R. Burton. This year's workshop will be held again during the Aerospace Medical Association Annual Scientific Meeting in Montreal, Quebec.

The workshop will take place at:

Room: Ramezay
Q.E. Fairmont Hotel
Thursday, 9May 2002
12:30 – 14:00 PM

This year's International Acceleration Research Workshop is generously sponsored by:

GENTEX

Thursday May 9, 2009;
12:00 – 2:00 PM

Room: Ramezay
Fairmont Q.E. Hotel
Montreal Quebec, Canada

2002 International Acceleration Research Workshop

Agenda

- Welcome
- Introductions
- Special Announcements
  (safety related events, requests for information...)
- Acceleration Web Page Dr. David Newman
- Discussion topic

  "Libelle Part II: Results of multi-lab investigations and comparison to existing anti-G systems"

- Discussion of newsletter articles and/or Laboratory/National Reports
- Other presentations
- Chair selection 2003

Linkoping Acceleration Research Report: Dr. O. Eiken MD, PhD

Most likely, the Dynamic Flight Simulator in Linkoping will be operational within a year.

Presently, all research projects are undertaken in the centrifuge at Karolinska Instutet, Stockholm. Completed or on-going projects/questions during the past year can be listed as follows:

• G-induced arm pain

- Acute and long-term effects of increased and decreased pressure in arm vessels

• Pulmonary function at increased G-loads

- Effects of increased G-load and anti-G suits on pulmonary gas distribution
- Effects of counter-pressure jerkin during pressure breathing at high G-loads

• G-tolerance

- Physical fitness and G-tolerance
- Effects of reduced Anti-G straining maneuvers on G-tolerance during PBG

• Spatial disorientation and motion illness

- Vestibular mechanisms involved in the development of “the leans” and “G-excess” illusions
- Effects of motion sickness on autonomic functions

Stockholm April 22, 2002

Report from Swedish Acceleration Program

"The Swedish DFS program have made a lot of progress this year. The man-rating reached a great milestone in April. Wyle and FMV (Swedish Defence Material Administration) man-rated the DFS up the present limits for manned operation. Our test pilots experienced 9 G with an on-set rate of 6 G/s. All profiles including the simulated air combat maneuver (SACM) was performed to our and the pilots satisfaction.

Earlier the maximum performance of the machine was demonstrated unmanned. The on-set performance was even higher than specified, 14G/sec from idle to well above 10G.

Some work remains to be done before initiation of training for the Swedish Air Force Pilots, but it has been clearly shown that the DFS satisfies our most critical requirements regarding g-levels and on-set rate."

RMIT Aerospace Physiology Laboratory

Annual Report

David G. Newman, *MB, BS, DAvMed, PhD, MRAeS*

RMIT Aerospace Physiology Laboratory, RMIT University, Melbourne, Australia

The last year has been a busy one for RMIT's Aerospace Physiology Laboratory. The lab now has a range of research projects underway, and 3 postgraduate students pursuing research activities in aerospace physiology. An in-flight research programme has commenced, with initial flights being limited to equipment integration & testing. The first flights were conducted in a Piper Warrior, and the lab has plans to expand this activity with the eventual use of an aerobatic aircraft to explore the +/-Gz environment.

APL has increased its available store of research and testing equipment. Recently we have acquired an ambulatory impedance cardiography device, for non-invasive determination of stroke volume and cardiac output. Construction of a lower-body negative pressure device is almost complete, and has already begun preliminary testing. A limited-capacity PC-based flight simulator is being established, for future use in various research projects.

Caroline Rickards is currently pursuing her PhD in aerospace physiology in the APL. Her project will involve using the LBNP device to explore cardiovascular function in the +Gz environment. During 2001, Caroline was a finalist in the Young Investigator Award, eventually finishing 6th out of 149. She is also the recipient of the 2002 AMSRO Travel Scholarship, which will enable her to attend the AsMA meeting & acceleration workshop in Montreal. She has a paper being published in the May 2002 issue of *Aviation Space & Environmental Medicine*, entitled "The effect of low-level normobaric hypoxia on orthostatic responses."

Narelle Berry is currently a Masters student in the APL, having graduated with a First Class Honours degree in 2001. She will be presenting her 2001 work during the AsMA meeting this year. Her project involved an investigation into the effect of caffeine on orthostatic tolerance. Her Masters project will involve further investigation of the effect of caffeine on orthostatic tolerance, by using a combination of orthostatic stressors such as LBNP and aerobatic flight. Richard Mallows is an Honours student, whose project will involve an investigation into the effect of lateral G on the cardiovascular performance of racing car drivers.

In other areas, APL is involved in a number of collaborative projects, both within Australia and overseas (e.g., Canada). For further information, please contact the laboratory's Director, Dr David G. Newman via email at david.newman@rmit.edu.au

NAVAIR Report Dr. Barry Shender

1. Completed SAILSS (Smart Aircrew Integrated Life Support System) evaluation in BAFB centrifuge, September 2002. Results will be presented at AsMA 2003 by Estrella Forster, Barry Shender, Bill Fraser, and Paul Werchan. SAILSS includes dry physiologic sensors incorporated into a Combat Edge vest and helmet. The evaluation demonstrated the ability of SAILSS to communicate with other aircraft systems.

2. SAILSS continues to be a Defense Technical Objective (HS.26) and has been included in the Office of Naval Research Future Naval Capabilities (FNC) program thru 2007.

3. TAILSS (Tactical Aircrew Integrated Life Support System) is a start up also approved as an FNC program thru 2007. As part of the program, the feasibility of the German GKSA design will be investigated.

4. Neck injury prevention during maneuvering acceleration program is continuing, also with FNC funding. This includes isometric and dynamic neck strength / endurance testing and injury modeling. NAVAIR has also developed a "G-Load Simulator" which combines a virtual reality flight simulator with a closed-loop control system capable of reproducing head/neck loading associated with maneuvering acceleration. This will be used to investigate the effects of varying work/rest cycles on the ability of the neck muscles to tolerate repetitive loading while flying realistic flight maneuvers.

Report from the Dynamic Environment Simulator centrifuge facility, Wright-Patterson AFB OH, May 2002 Bill Albery

Since last May, we have been completing three major studies on the centrifuge. One study involves GLOC. This was a four-experiment study with two of the experiments on the DES and the other two on the AFRL centrifuge at Brooks AFB. The results of these experiments were presented here at this meeting. The second major study completed over the past year was the helmet biodynamics research. Ed Eveland presented these results here, in Montreal. The third study is the G layoff study with the Navy (Pensacola). This study began in 2001 and is still underway in May 2002. A summary of these studies and others follows:

GLOC Phase II data analysis completed: The data from the reduced recovery acceleration levels phase of the USAF-Navy G induced loss of consciousness program have been analyzed. The purpose of this phase of research was to determine if a pilot recovered from a GLOC sooner if he/she was able to recover from the GLOC at less than +1 Gz. This would mean the GLOC would have to be detected and that the aircraft could be rolled over 180 degrees or decelerated to produce the less than 1 Gz environment. The premise is the reduced gravity would enhance blood volume return to the head, thus increasing eye level blood pressure and brain function. Phase I results showed that subjects did not recover sooner as a function of the number of exposures to GLOC. The total recovery period was no different after the fourth GLOC compared to the first. In this Phase II research, subjects were exposed to –1 Gz, -0.5 Gz, or + 1 Gz subsequent to GLOC. The post-GLOC recovery data indicated a trend toward reduced relative incapacitation recovery time for profiles less than +1 Gz compared to the +1 Gz recovery G-exposure, however, these data were not statistically significant. There was no significant reduction in recovery time for the absolute or total incapacitation times. Both the tracking and math tasks performed during the GLOC exposure were halted prior to the actual GLOC event. Subjects stopped performing the math task for a significantly longer period of time compared to the tracking task. Fine motor control of the tracking task was degraded for approximately 34 sec following the GLOC event. Cognitive function, as measured using an arithmetic task, was impaired for 50 seconds following the GLOC episode. These two findings are new and pose serious implications for those pilots whom GLOC, then recover and have to maneuver their aircraft immediately after their recovery. GLOC research continues at Brooks AFB, where a second GLOC study will end in Jan 2002. Mr. Lloyd Tripp is the principal investigator on the GLOC efforts within AFRL/HEP.

Auto Racing Simulation discussed. In following up on the Championship Auto Racing Team (CART) /Texas Motor Speedway (TMS) incident one year ago, and General Lyles' (HQ AFMC/CC) interest in supporting the racing industry, HEPA has looked into the possibility of simulating on the DES centrifuge the conditions in a race car experiencing high Gz and Gy in the turns and exposing a driver to those conditions. Trice Motor Group, represented by Mr. Doug Hill, along with Dr Henry Bock, the Indy Racing League Medical Director and Phil Casey, the Technical Director, visited the DES facility 13 Feb and asked Dr Ted Knox and HEPA to develop a cost estimate to study the vestibular and Gz/Gy problems encountered this past year at the TMS. As a phase I approach to this problem, Dr Albery has suggested CART bring an experienced driver into the facility and have him experience a 'low G' simulation of the TMS in order to de-

termine if the centrifuge simulation is representative of racing conditions in the eyes of a driver. CART is looking at several dates in June 2002 to perform the evaluation.

Navy G-layoff study underway: The Navy's G-layoff study, being performed in the DES centrifuge, began 26 Oct. As of May 2002 ten subjects have completed the research study, which is examining the effect of layoff from G on pilot sustained acceleration tolerance. Several additional subjects are currently undergoing G training for the study in preparation for exposure to +7.5 Gz with no protection from an anti-G suit. Subjects are trained on the centrifuge and their relaxed and straining tolerances are measured. After their G tolerance has peaked, they are laid off once for 7 days and again for 14 days before returning to the centrifuge to have their G tolerances measured again. In addition to G tolerance, researchers are also monitoring the subjects' blood lactate levels before and after the exposures. The goal is to collect data from sixteen subjects in the study, which will run into July 2002.

Navy demonstration of portable physiological monitoring system: Navy representatives visited the DES facility at Wright-Patterson AFB 7 and 8 February to demonstrate the K4 b^2 CosMed^{TM} physiological monitoring system for possible use in the ongoing G Layoff research they are funding. This portable unit is an electrical medical device designed to perform pulmonary function tests. It is expected to be useful in obtaining data related to the endurance aspects of fatiguing, high G performance. The CosMed^{TM} monitor makes calculations at the end of each breath for parameters including: VO_2, VCO_2, VT, HR, VE and several others. From these calculations, additional parameters indicative of energy expenditure can also be obtained. This system will be used to determine how human physiology might be affected during training and layoff periods. Changes in physiological variables might be useful in explaining changes in aircrew performance.

Gz Acceleration Induced Loss of Consciousness (GLOC) Neuromotor Performance results: Data recently collected as part of the Live Fire GLOC program revealed that full recovery from GLOC actually takes longer than previously reported. USAF and Naval researcher Dr Jim Whinnery reported that the GLOC experience, on average, lasted about 24 seconds. Incapacitation during a GLOC event was defined as a combination of the period of unconsciousness with the period of disorientation and confusion. The current study employed two performance metrics, a compensatory tracking (fine motor control) task and an arithmetic (high order cognitive function) task. Both tasks were accomplished simultaneously prior to and following the GLOC event. Subjects experienced GLOC on four separate experimental test days over a four-week period. Analysis of the performance data showed that subjects stopped performing the arithmetic and tracking tasks 8 and 3.5 seconds respectively, prior to the GLOC event. Additionally, post-GLOC performance recovery to pre-GLOC baseline values took on average 64 and 12 seconds for the arithmetic and tracking tasks respectively. The addition of the pre- and post-GLOC performance incapacitation periods to the total incapacitation time previously described by Whinnery increases the total incapacitation time period to 40 seconds before tracking ability is regained and 96 seconds to effectively perform the arithmetic task. These findings may have a profound effect on how the pilot incapacitation period is defined in the future and may prove valuable in the development of a GLOC autorecovery system (SAILSS) currently under development at the Naval Air Warfare Center.

Human Performance Modeling Under G kickoff meeting: An official meeting for the coordination of the SBIR phase II contract with NTI Inc. was held on 9 July 2001. Four employees of NTI, including Dr Bob

O'Donnell, the Principal Investigator of this effort, conducted the meeting along with the government contract technical representative (COTR), Dr Tamara Chelette. Two members of HEC's Combined Automated Requirements Testbed (CART) also attended. A work plan, an advisory committee, and an approach were agreed upon.

Helmet Biodynamics results - helmet aiming performance under G: A Resident of Aerospace Medicine (RAM) at Wright State University has completed his research using data collected in the Helmet Biodynamics research study. Mr. Ed Eveland is the Principal Investigator for the Helmet Biodynamics protocol. Nasser H. Al-Nuaimi, M.D., submitted a thesis entitled "Tracking Task Performance between Males and Females under Different G Environments" in partial fulfillment of the requirements for his Master of Science degree from the Department of Aerospace Medicine at Wright State University. The study showed no significant difference in helmet tracking task performance (up to + 6.5 Gz) between females and males. Means followed trends where increasing helmet weight or a change (forward) in the center of gravity resulted in poorer tracking performance; however, the mean differences were very small compared to the effects of task and Gz.

Cerebral Oximeter results of GLOC experiment: Dr. Talal Kamal, Wright State University Resident of Aerospace Medicine, found that cerebral blood volume and cerebral oxygen saturation (%rSO2) were significantly affected by G-induced loss of consciousness (GLOC). Dr. Kamal participated in the GLOC research being conducted on the DES centrifuge. Mr. Lloyd Tripp (Veridian), the principal investigator, worked with Dr. Kamal on the oximeter results of the study. Cerebral blood volume decreased from a 1.4 Gz (baseline) G exposure , on average, 15% at GLOC with a maximum decrease of 18% approximately 2 seconds after GLOC. When subjects regained consciousness, on average 13 seconds after GLOC, both blood volume and %rSO2 were near baseline G levels. When subjects were back on the tracking/cognitive task, on average 28 seconds after GLOC, blood volume and %rSO2 were 5% above pre baseline levels. Interestingly, the %rSO2 at GLOC of the female subjects was 19% less than pre baseline levels while the male subjects were only 10% less than pre baseline levels ($p=0.0205$). There were no significant differences in the changes of oximeter readings from pre baseline across the 4 exposure days.

Bradycardia observed during GLOC experiment: Another WSU RAM has recently completed his M.S. thesis on the DES centrifuge. Kevin Templar, M.D., piggy-backed on the GLOC study. He analyzed the results from the positive to negative Gz exposures during the second phase of centrifuge GLOC tests**.** His thesis is entitled "The Bradycardic Response in Humans During Negative Gz Exposure."

Dr. Templar's interest was in the changing heart rate. His conclusions were that there was a significant difference in heart rate response between the +Gz and the two –Gz conditions used in the study. But no significant effect in heart rate response was noted between the two levels of –Gz exposure. One subject demonstrated no changes across all three experimental parameters. One subject demonstrated a dropped beat or brief sinus arrest during the positive runs. The subjects also demonstrated a gradual recovery from any lowering of the heart rate, back to baseline values. Subjects were immediately exposed to +1 Gz, -0.5 Gz, or -1Gz subsequent to GLOC to determine if these brief negative G exposures reduced their period of total incapacitation subseqeunt to GLOC.

Despite some limitations of the study, this study may shed some light on the effects of negative Gz acceleration and its impact on pilot recovery from GLOC. In this study there was a noted statistically significant drop in heart rate from the initial baseline mean heart rate for each Gz exposure condition. There was a modest heart rate change from the baselines of 112.0 and 116.9 beats/minute (bpm) to 96.0 and 96.6 (–16.0 and –20.3 bpm respectively) corresponding respectively to the –0.5 Gz, and –1.0 Gz exposure conditions.

This reflex vagal response is principally caused by an increase in the carotid sinus baroreceptor activation, due to a cephalic shift of fluids noted under a negative G field.

Phase I SBIR completed: The Phase I SBIR (Small Business Innovative Research) contract with NTI, Inc was concluded upon the receipt of their final report. The report described the feasibility of creating a human performance model that accounted for cognitive deficits caused by high G forces. It also describe the potential to develop a test battery for further study of the multiple dimensions of cognitive effects and the development of a tool that could be used to design training and tactics with respect to the anticipated G forces. Such a tool may also prove useful in mishap reconstruction. The products are similar to those already developed for the Warfighter Fatigue Countermeasures team in HEPM, Brooks AFB. The feasibility report was so positive that it was the basis for a successful selection for Phase II funding.

Book Chapter published: The chapter entitled "Performance Effects of High G Environments" has been published in the *International Encyclopedia of Ergonomics and Human Factors*. The encyclopedia has been published by Taylor & Francis, London, and has over 800 chapters and articles covering the topics of ergonomics and human factors. Dr. W Karwowski of the University of Louisville, is the editor. The chapter is a summary of the acceleration performance research conducted on the Dynamic Environment Simulator (DES) centrifuge during the past 20 years.

Albery, W. Performance effects of high G environments, chapter in *International Encyclopedia of Ergonomics and Human Factors*, 2001, Karwowski, Ed, Taylor & Francis Publishers

Spatial Disorientation Phase II SBIR: Creare Inc. of Hanover NH was awarded a phase II SBIR contract for their topic of "Spatial Disorientation and Prediction System." The award is for $746 K for the 24-month effort. Dave Kynor (Principal Investigator), Dr. Anthony Dietz, Dr. Joel Berg and Dr. Marc Kenton of Creare will continue their work on predicting and detecting spatial disorientation in pilots, with a pilot warning system for the cockpit and a human perception model for HEPA as the final products. Their products will include a PC-based program utilizing X-PLANE that displays the actual orientation and pilot's perceived orientation during maneuvering. This effort is in support of the Spatial Disorientation Countermeasures research program.

DRDC Toronto

Acceleration Research Report

Dr. Len Goodman

Following from our transition to Federal Agency status last year, the entire organization as well as each research establishment officially changed names April 1, 2002 . This is changed from: Defence and Civil Institute of Environmental Medicine (DCIEM) to ***Defence Research and Development Canada – Toronto* (*DRDC Toronto*)**. E-mail addresses have also changed to Firstname.Lastname@drdc-rddc.gc.ca

The original DRDC Toronto human centrifuge was operational for 8 months for training and research activities, but has recently been taken out of operation once again. A second phase of safety interlock upgrades is in progress in order to further enhance safety and reliability. In the meantime, the new arm and gondola installation project (purchased last year from I.L. Poland) continues to progress. Safety and functionality analysis leading up to software development is occurring, in addition to procurement of ancillary hardware components.

Dr. Fred Buick and graduate student have completed Phase I of ONR – funded research: Air combat maneuvering involves repetitive +Gz excursions and it is important to know if +Gz tolerance changes during such situations. Unprotected subjects rode the centrifuge in simulated air combat maneuvers composed of 10, successive, rapid-onset +Gz cycles separated by short periods at +1.4 Gz baseline. Compared to the responses in the first cycle, head-level blood pressure and vision were improved during the succeeding cycles, the improvements being greater if the period between cycles was 1s rather than 15 s. These responses suggest relaxed +Gz tolerance is improved in acute, repetitive +Gz exposures. (Lalande S, Buick F. Improved +Gz Tolerance In Short-Term, Repetitive Exposures To Acceleration. Aviat Space Environ Med 2002, 73:305.)

Dr. Len Goodman has installed a seated LBNP chamber on the tilt table, and can apply slow or rapid-onset LBNP stimultaneously during Head-Up / Head-Down tilting. This will be exploited in future tilt table laboratory experiments. Dr. Goodman completed data analysis of neck chamber pressure during push-pull experiments conducted on the WIML centrifuge (Warsaw, Poland) in Feb/March 2001 This data was presented at the meeting (Goodman, et al. A.S.E.M 73(3) 304). Results indicate that attempts to normalize carotid sinus transmural pressure using a pneumatic neck chamber during the –Gz phase have very little effect on ameliorating physiological responses to push-pull maneuvers (despite evidence that this should be so from animal studies). This is most probably due to the very strong stimulation that other baroreceptor populations receive during –Gz which countermand simple perturbations to the carotid sinus, not to mention baroreceptor resetting and opposition effects.

Mr. Bill Fraser and his multi-disciplinary contractor team continue to be very productive. He has collaborated with USAF studying statistical indices relating to modeling and simulation of +Gz; advanced software architecture for acceleration data analysis; mathematical modeling of baroreceptor, cardiac and peripheral hemodynamics. Several abstracts have been presented at this years' meeting.

OTHER RESOURCES OF INTEREST

Aviation Medicine Home Page: http://www.ozemail.com.au/%7Edxw/avmed.html

SPECIAL THANKS

Thanks to Gentex Corporation for generous sponsorship of this event.