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Dynamic Testing of a Helicopter Emergency Egress Lighting System for Survival Systems Group Ltd

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Dynamic testing of a Helicopter Emergency Egress Lighting System for Survival Systems Group Ltd.

D.R. Day

Defence R&D Canada

External Client Report
DCIEM ECR 2000-082
August 2000

National Defence Défense nationale

Canada

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Abstract

A test program is described to determine the performance effectiveness of the controller and power supply components of a prototype Helicopter Emergency Egress Lighting System (HEELS) system under realistic impact conditions. Two test packages were subjected to simulated impacts representing five different crash pulses. The power supplies withstood all the impacts, but the inertia switches failed once at the lowest impact condition, indicating a possible quality control problem, and a need to verify that the minimum expected impact would suffice to activate the system reliably.

Résumé

On décrit un programme d'essai visant à déterminer l'efficacité des composantes de commande et d'alimentation électrique d'un prototype de système d'éclairage aux fins de l'évacuation d'urgence d'un hélicoptère (HEELS) dans des conditions d'impact réalistes. Deux ensembles d'essai ont été soumis à des chocs simulés qui représentaient cinq différentes impulsions d'écrasement. Les blocs d'alimentation ont résisté à tous les chocs, mais les interrupteurs à inertie ont fait défaut une fois à la plus faible condition d'impact, ce qui laisse entrevoir la possibilité d'un problème de contrôle de la qualité et la nécessité de vérifier que le choc minimal prévu suffirait à activer le système.

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Executive summary

In an emergency situation, helicopter crew must often evacuate aircraft under extreme conditions. Survival Systems Group Limited of Nova Scotia has developed a "Helicopter Emergency Egress Lighting System" (HEELS) which incorporates a "light string" embedded in the floor or walls of a cabin to direct the crew to an exit in the event of an emergency. The light strip is activated by a controller which reacts to immersion, high acceleration forces, or excessive tilt. This report describes a test program which was carried out at DCIEM utilizing the Impact Studies Facility's HyGe Crash Simulator to determine the performance effectiveness of the controller and power supply components of a prototype HEELS under realistic impact (high acceleration) conditions. The Crash Simulator utilizes a rail-mounted sled to simulate impacts of aircraft and automobiles. Two HEELS test packages were subjected to simulated impacts representing five different crash pulses, one for each type of impact which helicopters are most often subjected to during crashes. The power supplies withstood all nine of the impacts, but the inertia switches experienced one failure at the lowest impact condition, indicating a possible quality control problem. In addition, regarding the relatively high severity of the crash pulses utilized, further study should be considered to identify whether the threshold crash level for light activation should be below that used in these tests.

Sommaire

En situation d'urgence, il arrive souvent que l'équipage de l'hélicoptère doive quitter l'appareil dans des conditions extrêmes. La société Survival Systems Group Limited de Nouvelle-Écosse a mis au point un système d'éclairage aux fins de l'évacuation d'urgence d'un hélicoptère (baptisé HEELS) qui incorpore une bande lumineuse intégrée au plancher ou aux murs de la cabine afin de diriger l'équipage vers une sortie en cas d'urgence. La bande lumineuse s'éclaire lorsqu'un contrôleur automatique réagit à l'immersion, à des forces d'accélération élevées, ou à un basculement excessif. On décrit dans ce rapport un programme d'essai exécuté à l'IMCME à l'aide du simulateur d'écrasement HyGe du centre d'étude d'impacts, dans le but de déterminer l'efficacité des composantes de commande et d'alimentation électrique d'un prototype HEELS dans des conditions d'impact réalistes (forte accélération). Le simulateur d'écrasement est muni d'un traîneau sur rail afin de simuler l'impact des aéronefs et des automobiles. Deux ensembles d'essai HEELS ont été soumis à des chocs simulés qui représentaient cinq différentes impulsions d'écrasement, soit une par type de choc que subissent généralement les hélicoptères en situation d'écrasement. Les blocs d'alimentation ont résisté aux neuf impacts, mais les interrupteurs à inertie ont fait défaut une fois à la plus faible condition d'impact, ce qui indique qu'il pourrait y avoir un problème de contrôle de la qualité. De plus, en ce qui concerne la puissance des impulsions utilisées, il faudrait songer à mener d'autres études afin de déterminer si le seuil d'écrasement servant à déclencher l'éclairage devrait être inférieur à celui qu'on a employé durant ces essais.

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The author would like to acknowledge the assistance of Mr. R. Miles, who performed the technical operations required to setup the sled and perform the sled firings.

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Objectives

The work described in this memorandum was carried out under a contract with Survival Systems Group Ltd. of Dartmouth, Nova Scotia, as part of a performance verification of a new "Helicopter Emergency Egress Lighting System" (HEELS) for use in US Navy (UH-60 series) helicopters. The complete system is comprised of:

(a) a Light String which is installed around the egress points of an aircraft to indicate an escape route for crew members, and

(b) an integrated controller and power supply incorporating a crash-activated inertia switch.

The primary objective of the test program was to determine whether the inertia switch would activate "ON" when subjected to a realistic crash deceleration pulse. A secondary objective was to determine if the controller/power supply could withstand the crash deceleration pulse. The light string was not part of the test program.

Test description

The tests were performed on the DCIEM 12-inch HyGe Impact Accelerator (Bendix Corp.), which simulates impact by rapid acceleration. The crash deceleration pulses which were delivered to the test package were programmed by the adjustment of various gas pressures and volumes within the impact accelerator, and by the selection of an appropriate internal metering pin. The test sled, with its payload, was accelerated to a predetermined velocity in a backwards direction. During the short period of rapid acceleration, the payload experienced dynamic loads identical to that which would occur during a decelerative crash. After the initial acceleration, the sled was slowly decelerated to a stop. This type of crash simulator is routinely widely used in the automotive industry for testing and researching restraint systems and new impact standards.

The payload (shown in Figure 1) consisted of two independent controller/power supplies (containing the inertia switches) supplied by Survival Systems Group Ltd.. They were mounted on the sled as shown in Figure 2. A LED was in place of each light strip, since the latter were not included in the test. The two LEDs, one for each of the two units, can be seen in the lower portion of Figure 2, mounted on a vertical board and marked "1" and "2". Since the sled can simulate a deceleration in one direction only, the orientation of the controller/power supplies was changed appropriately, depending on the pulse direction requirements.

Concerning the test crash pulses, generally crash data is not readily available for helicopters, and extensive analysis is required to determine crash pulse characteristics. However DCIEM has had experience working with the US Army in the testing of a new helicopter cockpit airbag system designed specifically for implementation in the Blackhawk (UH-60 series) helicopter. In the test program outlined in Ref. 1 , the US Army had analyzed extensive UH-60 crash data and had developed five idealized deceleration profile envelopes representing the most significant crash scenarios of the Blackhawk (UH-60 series) fleet. Deceleration pulses for these envelopes were later developed at DCIEM for use in a program with the US Army. In addition, since the prime candidate for first implementation of the HEELS was in US Navy UH-60 series helicopters, it was felt that the use of these pulses would be appropriate to assess light activation of the HEELS.

Each of the five pulse envelopes was modeled for a specific type of impact which was characterized by:

(a) the initial velocity of the helicopter

(b) the direction of motion of the helicopter

(c) whether the impact was onto land or water

The resulting five pulse envelopes are listed below. The 'target' envelope for each pulse is shown in the figures by the thick straight lines, while the actual pulse achieved in the tests at DCIEM is shown by the lighter curved line. In practice, it is very difficult to produce precise deceleration pulses. While a HyGe system is theoretically capable of closely approximating any profile, considerable time and expense can be incurred to accomplish this. For this program, in order to reduce costs and approximate the desired pulses, the HyGe system utilized existing techniques and hardware which had been developed and accepted previously by the US Army.

1. Vertical onto land with nose pitched down 30 degrees: $\Delta V = 66$ ft/sec (Figure 3). The initial flat portion represents the deceleration due to the collapse of the landing gear, followed by a rise in deceleration due to contact with the helicopter body.

2. Vertical onto water with nose pitched down 30 degrees: $\Delta V = 54$ ft/sec (Figure 4). This pulse is characterized by a relatively steep rise in initial acceleration, which is the most important feature of the pulse.

3. Frontal, 0 degree yaw: $\Delta V = 56$ ft/sec (Figure 5).

4. (iv) Frontal, 30 degree yaw: $\Delta V = 56$ ft/sec (Figure 6).

5. (v) Frontal, 70 degree yaw: $\Delta V = 22$ ft/sec (Figure 7).

Test equipment

A single high-speed video-camera (MotionScope 1000 system) operating at 250 frames per second was mounted offboard, providing a lateral view of the payload. This was used to determine if the LED's came on and the switches activated during the simulated impact.

Inertial data was obtained from an accelerometer on the sled, using preamplifiers to increase the signal strength. The signals were low-pass analogue-filtered at 5 kHz on board the sled, and were then transmitted along a low noise, flying-lead, umbilical cable to the recording and data reduction area. They were stored on disk on a Macintosh IIFX which digitized the input signals at a sampling rate of approximately 5 kHz. as specified for the required filter class by the Society of Automotive Engineers. The computer programs first performed digital filtering on the data, followed by scaling and velocity computations (by integration of sled acceleration). The raw data for all runs are being retained on disk at the Impact Studies Facility on an indefinite basis.

Test sequence and results

Data from all the tests is shown in the table below. The actual sled accelerations are shown in Figures 3 through 7 for pulses (i) through (v) respectively.

Impact Pulse Type	Run Number	Measured Pulse Values		LED Action	
		Vel. (ft/sec)	Peak Acc. (G)	#1	#2
(i) Vertical onto land, 30 deg. pitch	3551	65.4	39.4	ON	ON
(ii) Vertical onto water, 30 deg. pitch	3550	58.2	37.4	ON	ON
(iii) Frontal, 0 degree yaw	3549	55.7	31.2	ON	ON
(iv) Frontal, 30 degree yaw	3547 (setup)	54.1	29.2	ON	ON
"	3548 (final)	56.3	31.4	ON	ON
(v) Frontal, 70 degree yaw	3544 (1st setup)	16.6	11.7	ON	OFF
"	3545 (2nd setup)	20.7	16.8	ON	OFF
"	3546 (final)	23.5	16.5	ON	OFF
"	3552 (repeat*)	22.5	16.6	ON	ON

* a new switch was installed into each unit for this test

For pulses (iv) and (v), single and double setup impacts were required in order to achieve the best fit to the envelope. Since payload setup was minimal, both units were used during these "setup" tests to gather additional data, with little increase in effort. Therefore, in the second column in the table, these "setup" runs did not meet the desired pulse characteristics.

Acceleration plots were omitted for the "setup" pulses and the "repeat" run 3552, which was identical to run 3546. Also it should be noted that the same units, with their original switches and power supplies, were used repeatedly from the first test (run 3544) up to and including the second last run (3551).

Both switches activated ON in all tests except for one switch (#2) which failed to activate only for the three runs (3544, 3545 and 3546) for the lowest severity pulse (v). Of these runs,the first two were setup pulses: only run 3546 met the velocity target of 22 ft/sec. for this pulse. When new switches were installed into both units and the run repeated (3552), both switches activated.

For the most severe pulse ((i), vertical onto land), it was observed from the high-speed video pictures that the #2 switch did not activate until after the initial, flat portion of the pulse (which peaked at about 7 G's), while the #1 switch activated close to the onset of the first acceleration.

Discussion

For a successful test the switches were required to activate during the impact, and the power supplies to withstand the impact forces. The power supplies survived all the impacts. However, one of the switches (#2) had a deficiency.

The failure of switch #2, pulse (v), is in agreement with the failure of this switch to activate until after the initial, flat portion (7 G) of pulse (i). This same switch did activate later in pulse (i), and activated below 29.2 G in pulse (iv). This would suggest that this switch normally activated somewhere between 16.5 G and 29.2 G, and this is clearly too high. None of this analysis considers the change in velocity with time, which would have had a large effect on determining the activation times: however we have insufficient data here to determine any meaningful velocity effects on the switches' performance.

The fact that both replacement switches activated during the repeat test of pulse (iv), (run 3552), suggests that, in general, the switches may activate at the correct times, but may have a quality control problem, since we saw an overall failure rate of 1 in 4.

It should be noted that the impact pulses used represented realistic crash scenarios of moderate severity, sufficient to activate an airbag system. However, it is possible that there may be crashes of a lower magnitude such that an airbag system wouldn't deploy, but high enough that the lighting system should activate. Therefore these pulses may not necessarily reflect the absolute minimum impact level at which it might be desirable to activate an emergency-egress lighting system. Further study would be required to identify whether the threshold crash level for light activation should be lowered.

Conclusions

In general the controllers and power supplies supplied to DCIEM had a high success rate: however, the single switch failure in the least severe crash pulse suggests that:

a. The switch specifications should be examined to ensure that all switches activate below a velocity change of 22 ft/sec, and below a deceleration of 15 G's, regardless of their orientation, and

b. The issue of quality control of the switches should be examined.

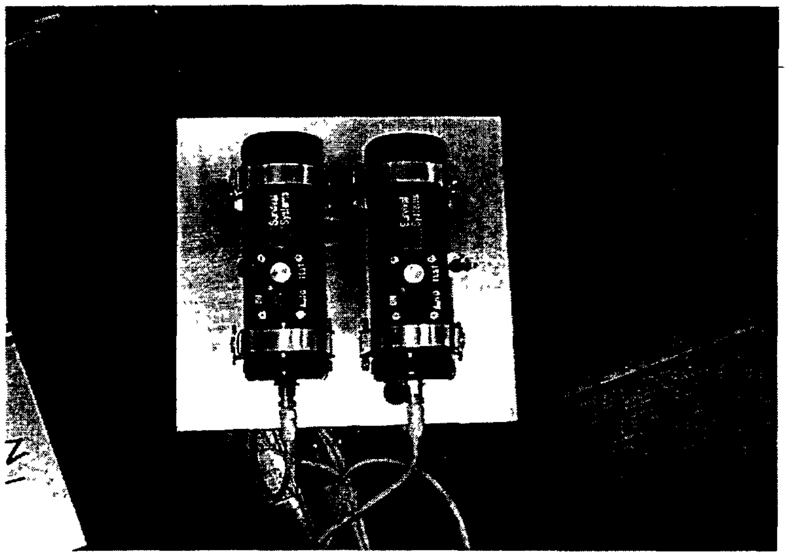

Figure 1. *Test payload: two integrated controllers and power supplies (each incorporating a crash-activated inertia switch)*

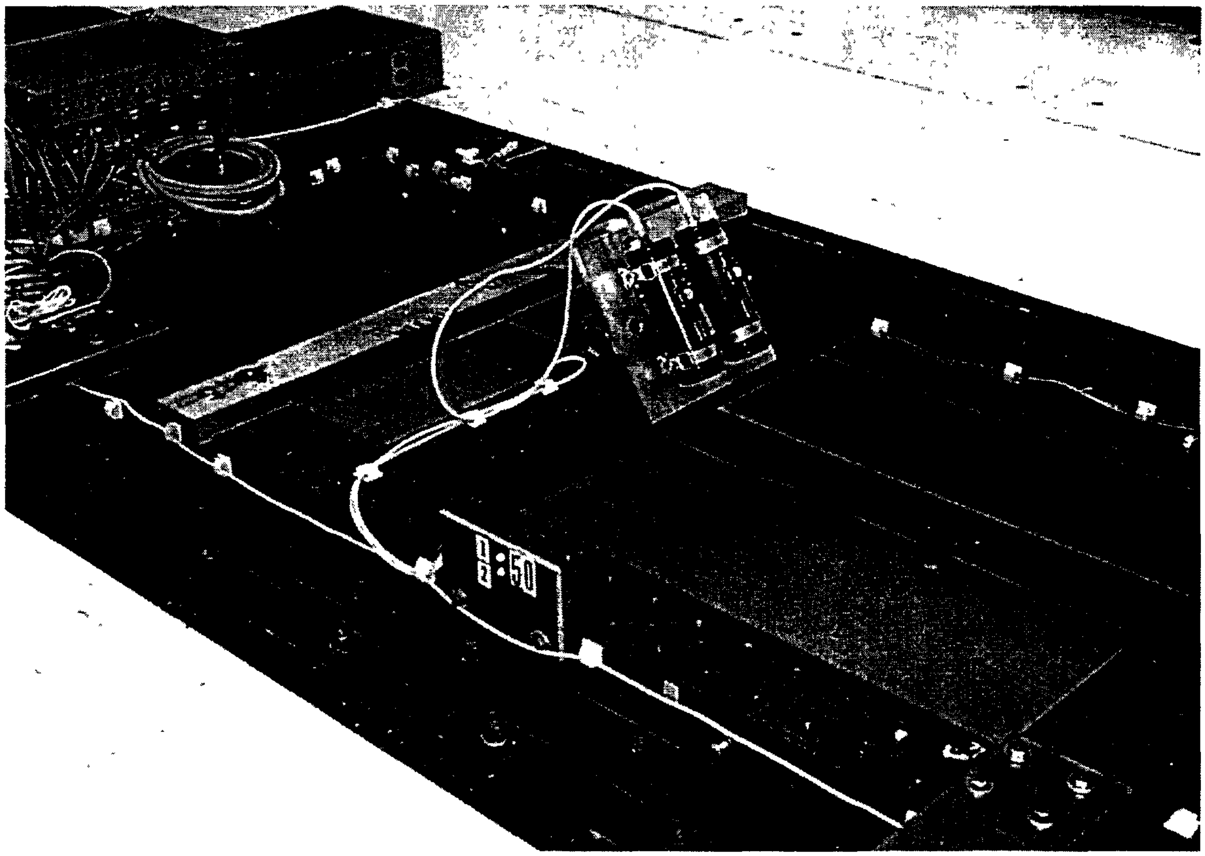

Figure 2. *Payload and LED display mounted on sled*

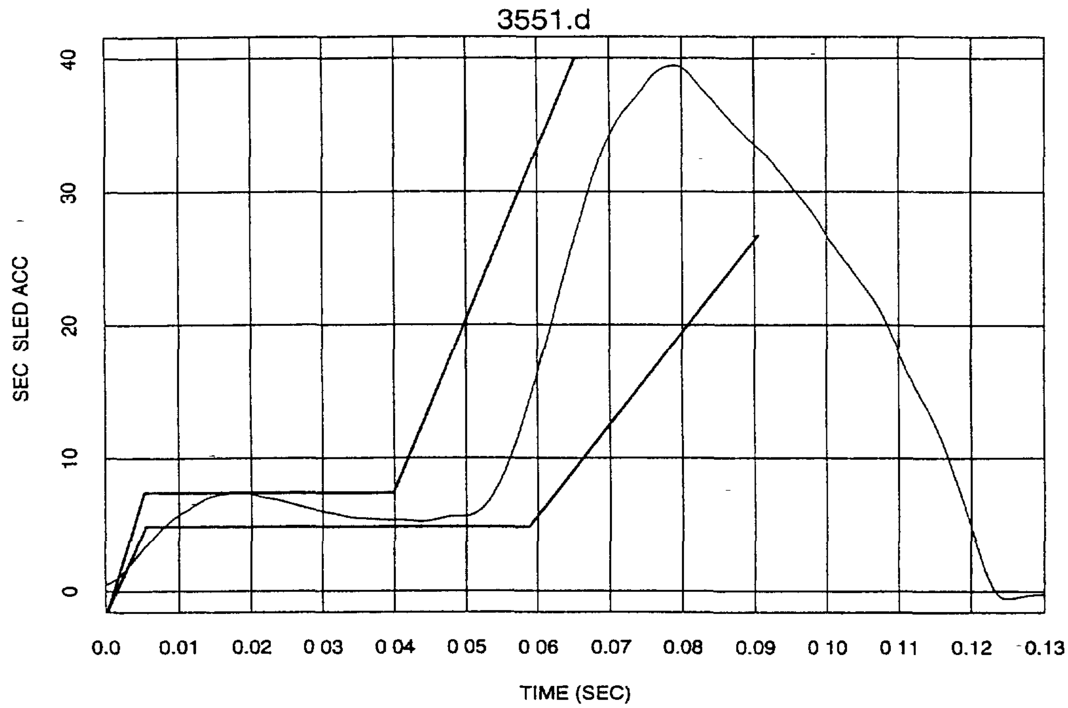

Figure 3. *Acceleration plot for pulse (i): vertical onto land with nose pitched down 30 degrees*

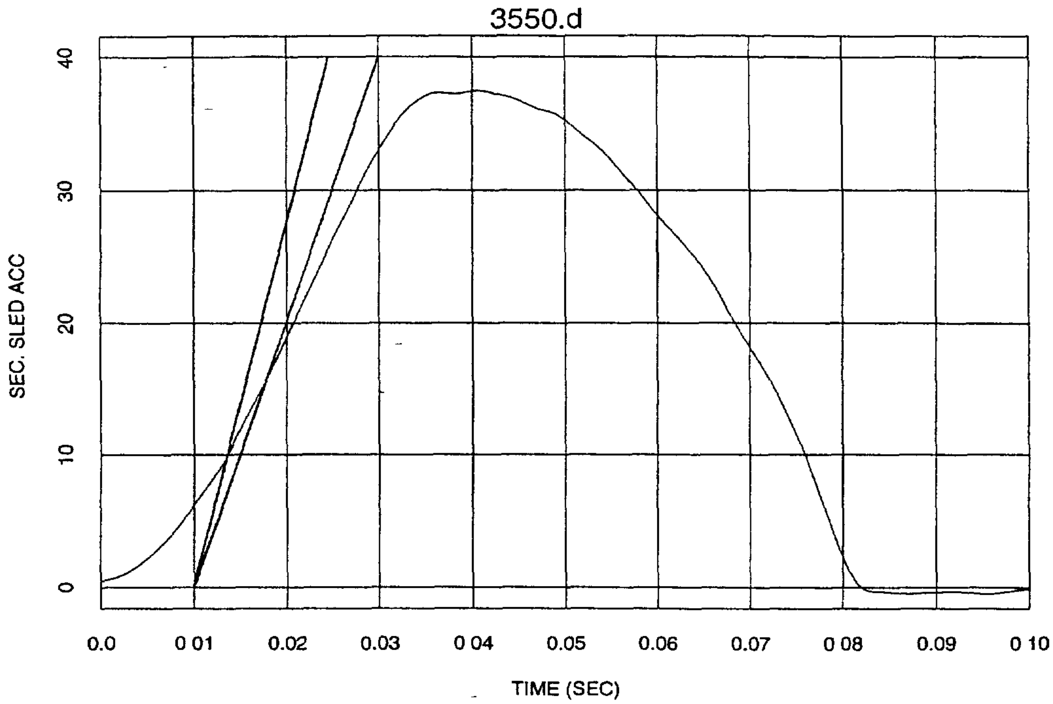

Figure 4. *Acceleration plot for pulse (ii): vertical onto water with nose pitched down 30 degrees*

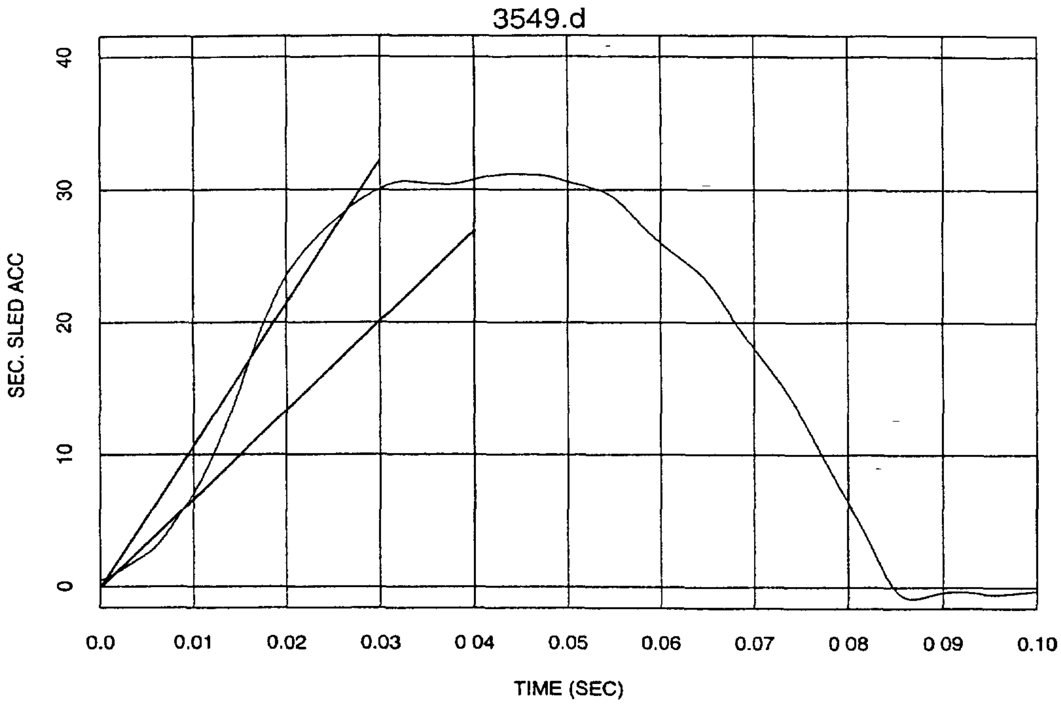

Figure 5. Acceleration plot for pulse (iii): frontal, 0 degree yaw

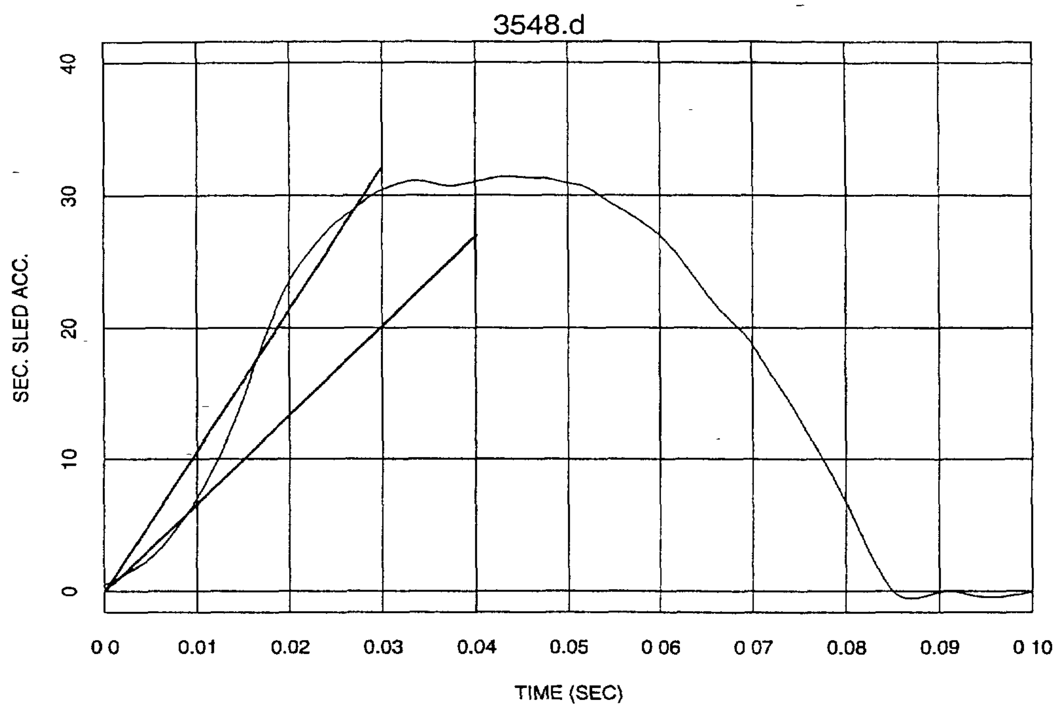

Figure 6. *Acceleration plot for pulse (iv): frontal, 30 degree yaw*

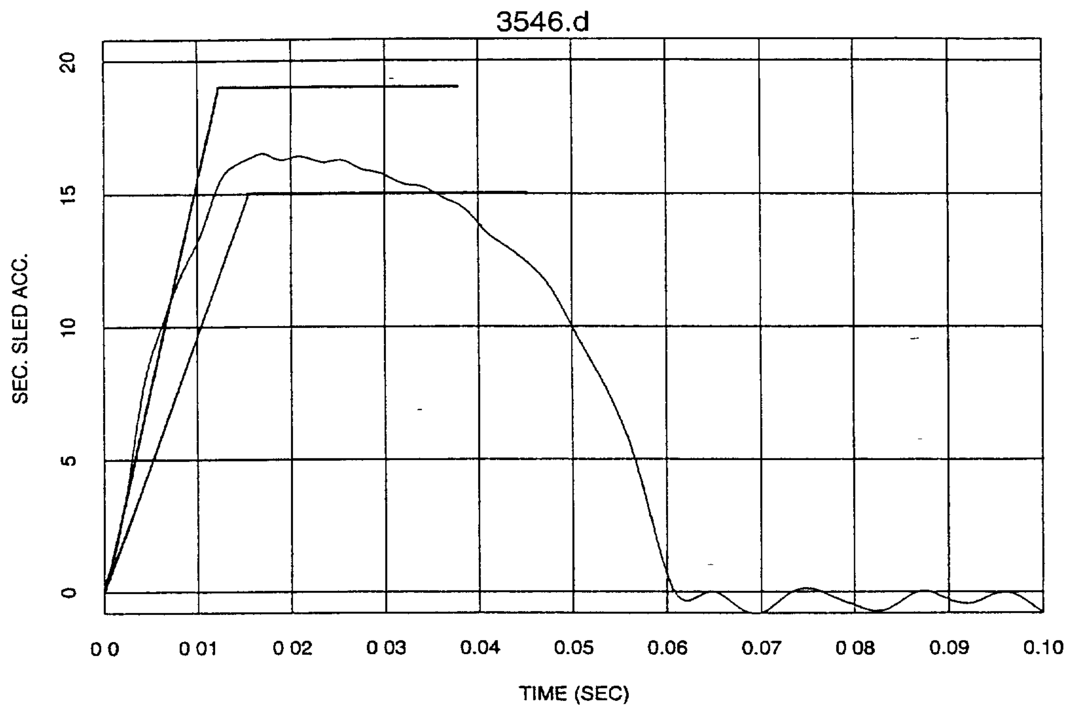

***Figure 7.** Acceleration plot for pulse (v): frontal, 70 degree yaw*

References

1. Dynamic Testing of the UH-60 Cockpit Air Bag System (CABS) at the Defence and Civil Institute of Environmental Medicine (March, 1997)

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