A METHODOLOGY FOR THE REDUCTION OF FALSE ALARM RATES IN ARTIFICIAL INTELLIGENCE-BASED LOSS OF CONSCIOUSNESS MONITORING SYSTEMS

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ABSTRACT: The concept of an artificial intelligence system-based loss of consciousness monitoring system is one which is receiving an increasing amount of attention in Air Force and industrial laboratories. The basic requirement of such a system must include as close to 100% reliability of decision-making as is possible as well as nearly complete "transparency to the pilot". This paper discusses a rationale for the design of a maneuver space boundary based on physiological data such that air combat maneuvers carried out below the edge of that boundary will constitute an indicator that a G-induced loss of consciousness is unlikely. Conversely maneuvers performed above that space (of G's and time) will serve to confirm indications from other sensors that a GLOC is possible and likely.

The concept of an artificial intelligence-based loss of consciousness monitoring system (LOCOMS) is one which is receiving an increasing amount of attention in Air Force and industrial laboratories. The basic requirements for such a system must include as close to 100% reliability of decision-making as is possible, as well as nearly complete "transparency" to the pilot. This line of argument was extended to the concept that the successful system will incorporate both aircraft and physiological parameters in order to more closely approach the ideal of no false alarms.

In the interim, industrial researchers have taken innovative and aggressive approaches toward this concept. In (2) Darrah et al have proposed a gas-tank model approach to the mathematical description of physiological reserves which, if implemented, should go far in the reduction of false alarm rates in a LOCOMS system. In this paper the author will present a simple concept which could provide a lower bound for the decision-making process of a LOCOMS system.

The G(rms) Model for +Gz Voluntary Tolerance: In (3) the author presented the results of an extensive descriptive modeling effort for the purpose of providing a broadly applicable metric for the severity of multiple, sequential acceleration exposures in the +Gz and +Gx axes. Based upon the vast amount of data available in the literature on these kinds of exposures, two models were developed describing the voluntary/fatigue tolerance of well protected, well trained, straining subjects, and the voluntary/fatigue tolerance of relaxed and unprotected subjects exposed to +Gz acceleration. The model for the well trained, protected, straining group has the form: $Gz_{(rms)}=17.03T^{(-0.26)}$ in which the rms value is computed in accordance with the procedure described in (3) and (T) is the time of exposure to the stress. The model for both groups is shown in Fig. 1. The model has not been extended below exposure periods of less than 30 seconds because of the wide variations in tolerance in that region. For example, it is known that man can tolerate virtually any acceleration in the +Gz axis (excluding impact types of acceleration) provided that the total period of exposure does not exceed the duration of protection provided by the brain's blood oxygen reserve. This phenomenon provides some interesting speculative material for what might be done in unconventional flight regimes but nevertheless leads to highly inflated values for exposure periods of ten seconds or less.

Structuring a Lower Bound for Automated System Judgements of Loss of Consciousness: From (4) and (5) and the other literature of acceleration physiology, a lower bound of +7.2Gz would be reasonable given the assumptions of a functioning anti-G suit and a pilot performing a 50mmHg strain. Over a period of 30 seconds this is not an unreasonable expectation for a well trained fighter pilot. The value of 7.2Gz is based upon the assumption of about 4.2Gz relaxed tolerance, plus and additional 1G for the anti-G suit, plus an additional 2G for a 50mmHg strain (assuming a conventional upright seat).

This value (7.2) intersects the model power function at a time of approximately 27 seconds and from that point, the boundary could be based on the power curve of the model out to whatever engagement duration is desired. A duration of 1000 seconds is shown in Fig. 2 simply for purposes of illustration. A computation period of 300 seconds is probably more realistic.

The surface below the boundary line can be said to represent a region in which maneuvers combining rms G's and time are unlikely to result in a G-induced loss of consciousness given the priori stipulations that the system has ascertained that, during each such contributing exposure, the pilot's anti-G suit was working, and that the pilot was doing a straining maneuver. Suit operation is easily verified, and the performance of an anti-G straining maneuver could be unobtrusively verified by oxygen mask pressure variations or by characteristic changes in anti-G suit abdominal bladder pressure.

Crossing the boundary line as a result of extended high G maneuvering could enable, first, a voice synthesized warning to the pilot to the effect that maneuvers are being flown in an area of increased risk and decreased physiological reserves. Such a crossing could also be used to adaptively alter other behavioral aspects of the system. For example, a positive crossing when the aircraft was less than 10,000 feet AGL could be used to reduce the period of time allowed by the system prior to pilot interrogation and intervention in control of the aircraft given the presence of other indicators of GLOC such as flaccid or non-existent grip on the stick, head lolling, fading characteristics in the straining maneuver, cessation of eye blinking, loss of cerebral pulse, and changes in skin opacity.

The methodology being proposed here is simple and probably practical. It can be refined by careful modifications that could arise from, for example, the knowledge base of exercise physiology and a well defined corollary of physiological reserves remaining as a result of successive acceleration exposures. Much of the information necessary to structure these refinements is probably available in the literature. The remainder represents an information need that the acceleration research community would do well to address.

References:

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BIOGRAPHY:

Dr van Patten took his undergraduate studies at General Motors Institute and postgraduate degree work in Human Factors Engineering and Bio-Medical Engineering at Columbia Pacific University. He has been associated with acceleration research at Air Force Aerospace Medical Research Laboratory at Wright-Patterson Air Force Base since 1963, holds many patents, among which is the original patent for the concept of electronic G-suit valves. He manages the acceleration research program at AAMRL and is currently running a program to exploit microprocessor technology in the areas of acceleration protection, oxygen systems and pilot physiological monitoring.

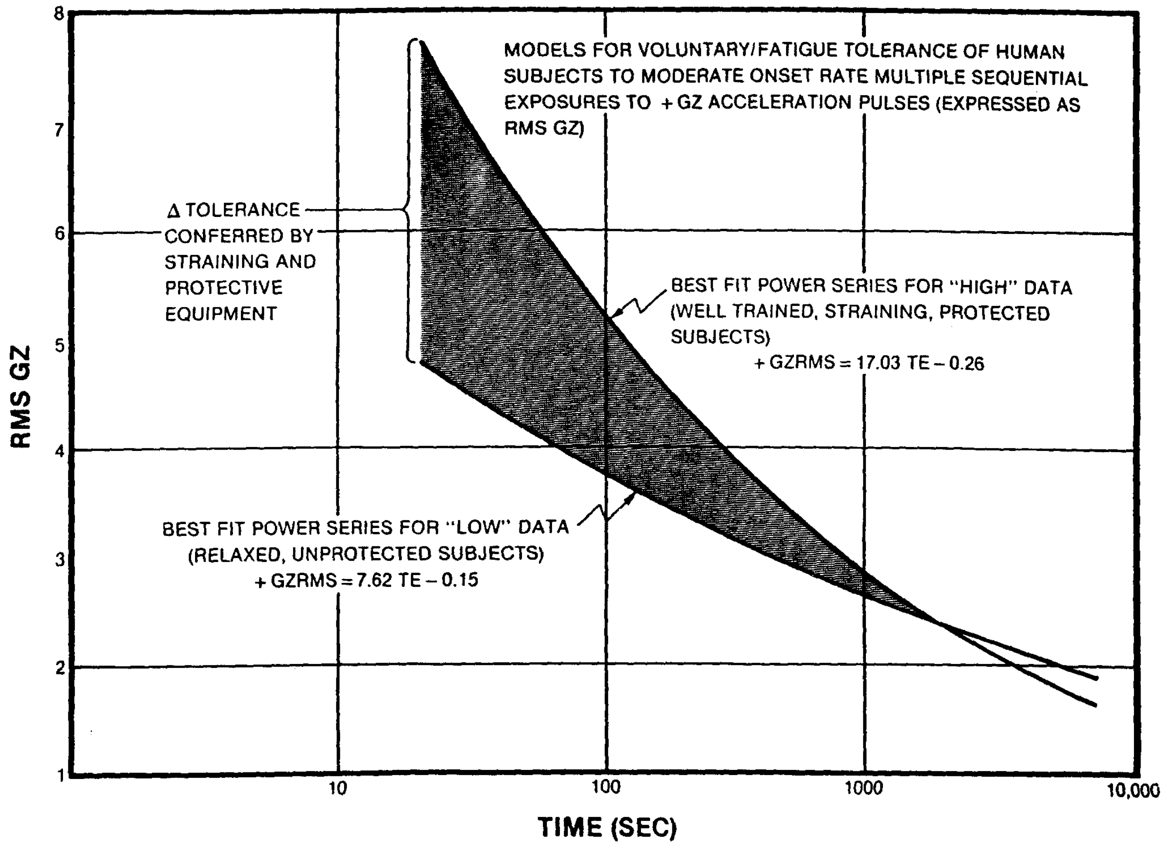
8
7
6
5
4
3
2
1
RMS GZ
10
100
1000
10,000
TIME (SEC)
MODELS FOR VOLUNTARY/FATIGUE TOLERANCE OF HUMAN SUBJECTS TO MODERATE ONSET RATE MULTIPLE SEQUENTIAL EXPOSURES TO +GZ ACCELERATION PULSES (EXPRESSED AS RMS GZ)
Δ TOLERANCE CONFERRED BY STRAINING AND PROTECTIVE EQUIPMENT
BEST FIT POWER SERIES FOR "HIGH" DATA (WELL TRAINED, STRAINING, PROTECTED SUBJECTS)
+GZRMS = 17.03 TE – 0.26
BEST FIT POWER SERIES FOR "LOW" DATA (RELAXED, UNPROTECTED SUBJECTS)
+GZRMS = 7.62 TE – 0.15

Figure 1

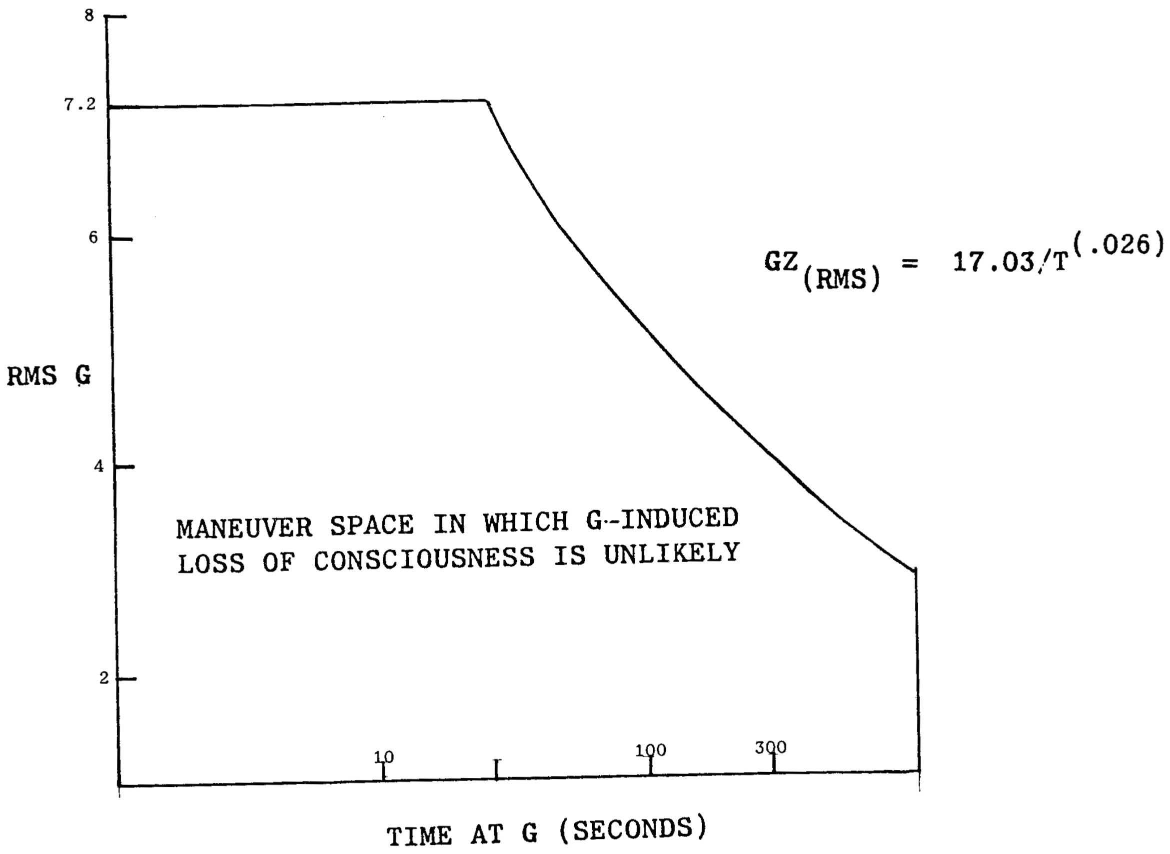
8
7.2
6
RMS G
4
2
GZ(RMS) = 17.03/T(.026)
MANEUVER SPACE IN WHICH G-INDUCED
LOSS OF CONSCIOUSNESS IS UNLIKELY
10
100
300
TIME AT G (SECONDS)

FIGURE 2