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Title of Prop. Research: Determination of Human Dynamic Response to Im...

Desired Starting Date: 1 July 1972

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Research Assistants: This is team research and a staff of about 20 civil service personnel is contemplated. Approximately 18 of these personnel are now on board and personnel actions to hire the remainder are in progress. Included amongst these personnel are:

1. Mr. William Muzzy - Chief, Engineering Division. Mr. Muzzy has served as the engineer in charge of the Daisy accelerator at the 6570th U.S.A.F. Aeromedical Research Laboratory, Holloman, AFB, New Mexico for 2,500 human and large primate exposures to impact acceleration.

2. Mr. Gilbert Willems - Chief, Instrumentation Division. Mr. Willems is an M.S.E.E. from Vanderbilt and is an expert in inertial instrumentation; hybrid systems analysis; and numerical analysis.

3. Mr. Scott Morrill - Chief, Physiological Instrumentation. Mr. Morrill has done physiological instrumentation for 15 years of the type contemplated by this study.

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and a B.S. M.E. from Massachusetts Institute of Technology.

[redacted] advanced development is being funded for FY 72 level of $300,000. Navy plans for FY 73 include an increase to $1,000,000. Funding from the Office of Naval Research is $250,000 for FY 72 and roughly the same in FY 73.

Information on the Organization: Naval Aerospace Medical Research Laboratory Detachment, Naval Aerospace Medical Institute, Naval Aerospace Medical Center, Pensacola, Florida 32512. The work will actually be perfo[illegible]d at the Naval Aerospace Medical Research Laboratory Detachment, Michoud Statio[illegible], Box 29407, New Orleans, Louisiana 70129. Person to contact on contractual matters: Principal Investigator.

CAPT Channing L. Ewing MC USN

Type of Project: Advanced Development

Description of Proposed Research: The technical objective is the precise description of the human dynamic response to impact acceleration in terms of linear and angular accelerations, velocities and displacements. The description will be dependent on the static properties of size, shape and mass distribution of volunteer subjects. It will also account for peak acceleration, duration of acceleration, rate of change of acceleration, direction of acceleration, and other significant independent variables as applied to the human subject. The dynamic interrelation of essential body components during the experimental dynamic event will be described. With this description , correlation of the physiological effects to impact acceleration will be experimentally determined. Further correlation of physiological effects and structural failure of the chimpanzee and structural failure of post mortem specimens will be implemented as the essential human descriptive information becomes available during Fiscal Year 1973 .

Hypothesis: The experimental hypotheses to be tested are:

1. That the [illegible] successful [illegible] [illegible] [illegible] [illegible] function of controllable experimental variables.

2. That the physiological effects and structural failures (i.e. injury) are related to the dynamic response.

3. That the human dynamic response is usable as the most effective predictor of injurious effects and structural failure.

Background: The goal of this research is to develop an evaluation method and design criteria for aircraft crash protective systems. The dynamic response of living man will be measured to the limit of voluntary human tolerance; it will be extrapolated beyond that point by experiments on living human analogs which have been metered to the human response by identical runs below the limit of voluntary human tolerance; and the portions of the human dynamic response envelope which are injurious and lethal will be determined by experiments on human analogs.

The input envelope will be in regular increments of the following variables, to the limits noted:

1. Peak acceleration - 200 G
2. Rate of onset - 4000 G/sec
3. Duration at Peak - 4 increments
4. Subject size - 3rd, 50th, 98th percentile sitting height
5. Vector directions - at least 20 different

All data collected will be in ADP compatible format and ADP will be used wherever possible.

Previous Work: This program was initiated in 1966 as an exploratory development program using Navy project director and research personnel; Navy computer; Navy Experimental Design; Army research personnel and volunteer subjects; Army 6.2 funding; and considerable Army logistic support under the Joint Army-Navy Flight Medicine Research Panel.

Research Laboratory (USAARL), Ft. Rucker, Ala. Physical and mental evaluation was [illegible] Florida.

Experimental exposures to impact acceleration were conducted at Wayne State University, Detroit, Michigan. 236 runs were completed in 1969 without injury and with very few run "failures" due to poor instrumentation, or photography, or both. ADP programs for data reduction have resulted. These data are the finest ever obtained in impact accelera[illegible] research on living subjects, animal or human. Values of 70 seperate variables m[illegible] continuously through time sampled every 1/2 millisecond, precise to a previou.ly unknown degree are available on about 200 runs.

During the past 12 months, the following has been accomplished:

1. A large modern building in New Orleans with good security, air conditioned, heated and lighted has been obtained from NASA with use of enough land for an extended track. This building has 96,000 square feet of floor space, of which about 40,000 is NAMRL office and laboratory space.

2. An urgent minor military construction project covering construction of the enclosed environmentally controlled track foundation and installation of 700 feet of track is near completion.

3. A 225,000 pound thrust accelerator with sled, control console and track are being installed.

4. A State-of-the-Art Data Acquisition System, designed to acquire all inertial data from human and primate subjects and digitize it in real time is being installed.

installation, and rearrangement of laboratory spaces to new use is about $900,000. Estimated

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6. Data from 1969 runs have been digitized, scaled and are undergoing analysis. Both the Department of Transportation and the Society of Automotive Engineers have requested these data. An extensive report is therefore in preparation. Over 100 variables are available for each run and 185 runs are available for complete analysis, to date.

7. Unlimited access to one of the largest digital computers in the world is available to the NAMRL research team for use in analyzing the data rapidly on [illegible] ficiently. Computer costs are economical due to availability of this large modern N[illegible] f[illegible]ility.

8. Delta Regional Primate Research Center has joined [illegible] a joint research program with NAMRL to allow NAMRL to use large primates with all the wealth of resources available to Delta.

9. A vertical accelerator with 40,000 pounds of thrust and facilities for x-ray cinematography with image intensification are available. Funding for installation and use of this facility over the next several years has been made available by the Office of Naval Research. The Data Acquisition System noted above will be used in conjunction with the vertical accelerator also.

10. A staff of 18 experienced technical personnel has been formed into an integrated team to perform this research. Seventeen of these are permanent civil service.

Methods: The experimental design involves the selection of human volunteer subjects encompassing the size and shape of the U. S. military population, who are then exposed to a series of acceleration profiles. The acceleration profiles are selected on the basis of peak acceleration, duration at peak, rate of onset and direction to encompass the dynamic response of the subjects within safe voluntary tolerance limits. Each individual is subjected to the runs

selection of individual run profiles is the safety of the human subjects.

During the experimental exposure, dynamic response is measured by inertial transducers mounted on the subject's head, mouth, base of neck and base of spine and by time-locked othogonally-mounted motion picture photography. The physiological status of the subject is monitored immediately prior to and after the exposure by recording electro-cardiogram, electroencephalogram and respiration. Other selected physiological variables will be recorded as required.

The recorded data for each run will be subjected to exhaustive digital computer analysis. After representation of the dynamic response as a function of the independent variables of the experiment, it will be possible to correlate the physiological response to the mechanical response on an individual and on a statistical basis.

Although the methods described were considered new at the inception of the program in FY 1967, the results of the experiments to date have established these techniques as standard to the program.

Various support programs will be continued to determine (1) techniques of estimation of mass distribution of an individual subject, (2) most pertinent anthropometric data for each subject, and (3) long range clinical effects of the acceleration exposures to each subject after the subject is no longer actively engaged in experimental runs.

...of new transducer mounts for the 3-D ...sy... ...n, performance of low (3 - 10G) runs on the new subjects and ...ase levels to higher peak acceleration; higher rates of onset of acceleration; determination of the effect of variation in duration at peak; debugging of new data acquisition and processing equipment and selection of an optimal method for mathematical modeling of results.

Military Significance: The problem addressed by this development program is that of protection of military personnel fro... ...e effects of impact acceleration, whether due to helicopter crashes, fixed wing c... ...s or ejection. Helicopters are the only type of aircraft from which there is no emerg...ncy escape. Various ideas for development of an emergency helicopter escape system have been proposed, but the success of any candidate design must be determined in actual use, since there is no information on the human dynamic response envelope and that portion of it which is injurious. Yet these are the data required to design and validate a dummy which can be used to evaluate the helicopter escape system, or other occupant protective system which can be used to reduce aircrew mortality in the absence of an escape system. Recent procurement by the Army of fire-avoidance equipment for helicopters has been quite successful, and the problem of crew protection now devolves upon protection during crashes.

The basic assumption upon which this work is being performed is that since a crash is a random, non-repeatable event, reproduction of irregular crash acceleration inputs to human and human analog subjects will not give reproducible results. Reproducible results can be achieved however by subjecting the human and human analog to small increments of input variables which are carefully controlled. The assumption is that a human analog (such as a dummy) which reproduces

onset, duration at peak, subject size and vector direction) will also represent the dynamic response of man to the complex accelerations normally experienced in vehicular crashes. If, then, the portions of the dynamic response envelope which are injurious can be used to establish injury threshold limits, the design criteria for protection of man from impact acceleration will be definitively established.

In summary, success of this program will make a war cheaper to fight from the point of view of operational mission aircraft replacement costs, and from the point of view of maintenance of combat operational capability, by preventing fatalities from crashes.

Facilities:

Accelerator: The largest most controllable and yet most flexible accelerator available for human subject use in the free world is under construction for this project. Completion of all phases is expected in July 1972. The track will be 700 feet long, and peak acceleration obtainable at the acceleration end will be 200 G.

Primate Facilities: Delta Regional Primate Center about 35 miles away from the experimental site is one of the two primate centers in the U. S. which could support this project facilities and is under contract to do so.

Computer Facilities: One of the largest digital computers in the world is available only 18 miles away from the experimental site. Investigators have almost unlimited access at very favorable rates.

Proposed Budget:

1. Salary costs: All salary costs for investigators will be borne by the U. S. Navy. The amount in FY 1973 will be approximately $400,000.

3. Consumable Supplies: All costs will be borne by the U. S. Navy.

4. Travel: $5,000 requested for [illegible]el.

5. Publication Costs: All costs will be borne by the U.S. Navy.

6. Other Direct Costs: None

7. Indirect Costs: None

8. No Fee

9. Total amount requested from USAMRDC: $5,000

NOTE:

The most important contribution requested is that of 21 Army volunteers for duty as subjects in acceleration/deceleration experiments, to be selected as in previous years on this project. These volunteers will be assigned with station at the Naval Aerospace Medical Research Laboratory Detachment in New Orleans. Suitable government quarters are not available, and all personnel will be drawing commuted rations; BAQ; and hazardous duty pay for experimental stress.