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16. Abstract (MAXIMUM 200 WORDS)

This report presents an overview of the joint U.S. Coast Guard and Transport Canada-sponsored project to develop new research tools for evaluating personal floatation devices (PFDs). The U.S. Coast Guard and Transport Canada entered into a Joint Research Project Agreement (JARPA) in 1992 to develop new research tools to improve the understanding of the complicated effects of rough water on the performance of PFDs. Two tools were developed: 1) a computer simulation program called the Water Forces Analysis Capability (WAFAC) which simulates human body movement in a water environment, and 2) a sophisticated Sea Water Instrumented Manikin (SWIM) which can be used in the water to gather information on how the body reacts to the water environment. Preliminary testing of these two tools took place at the Institute for Marine Dynamics in St. Johns, Newfoundland, Canada, in February and March of 1999. Testing of the SWIM was completed for a variety of simple cases in still water and in simple wave fronts. The same tests were simulated using the WAFAC computer model and some test data from SWIM. The results of the comparison of these tests, real and simulated, will help to establish continuity between the two tools. The testing identified some problems with the sensors having inadequate ranges for these tests. General agreement for rise times to the surface for bottom release tests was established. There was approximate agreement in heave amplitude and frequency, while other tests required the adjustment of coefficients. It was determined that better measurements of the center of gravity and buoyancy are needed for baseline inputs for the WAFAC program.

17. Key Words	18. Distribution Statement
SWIM, manikin, PFD, WAFAC, DYNAMAN, JRPA, U.S. Coast Guard, Transport Canada, IMD	This document is available to the U.S. public through the National Technical Information Service, Springfield, VA 22161

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EXECUTIVE SUMMARY

This report presents an overview of a jointly sponsored project by the U.S. Coast Guard and Transport Canada to develop new research tools for evaluating personal floatation devices (PFDs). The U.S. and Canadian governments require approval for PFDs used in the boating community and promote research to develop safer PFDs.

At present, PFDs are only evaluated for U.S. Coast Guard approval using calm water testing in which a person wearing a PFD enters the water and simulates an unconscious state. The PFD is then evaluated for floatation and righting ability. This calm water testing cannot accurately address the effects of that same PFD in the rough water environment. A more robust testing method could safely test and better evaluate the PFD in a wider range of water situations. To this end, two research tools have been constructed and are reported on. The first tool is a full-size waterproof manikin, which represents an average male in stature, weight, and buoyancy. This manikin was constructed to collect data on how an average male floats and responds to water forces. The second tool, a computer simulation program, simulates an average male's movement in the water environment. The manikin was used to gather input data for the computer simulation model. This report describes tests using the manikin in the water environment and compares the results of the computer simulation model of those same tests.

The U.S. Coast Guard and Transport Canada entered into a Joint Research Project Agreement (JRPA) in 1992 to develop new R&D tools to improve our understanding of the effects of rough water performance of PFDs. There is little information about the performance of life jackets in rough water, and methods are not available to extrapolate the rough water performance of a PFD from calm water testing. A computer model simulation was developed at Wright-Patterson Air Force Base based on the existing articulated Total Body Manikin (ATB) program written. The ATB program is used to evaluate the three-dimension dynamic response of a system of rigid bodies when subjected to a dynamic environment. The ATB program has been used for many years to study subject response to aircraft ejection and automobile crashes. The new program, developed jointly by the U.S. and Canada, is referred to as Water Forces Analysis Capability

(WAFAC) and has adapted the ATB model to the in-water environment. To complete the WFAC program, we had to verify the program using test data from the sophisticated Sea Water Instrumented Manikin (SWIM).

In conjunction with the development of the WAFAC program, a sophisticated SWIM was constructed and evaluated as a standard for testing PFDs. This manikin was used to gather data to validate the WAFAC model. SWIM is an anthropomorphically correct mechanical representation of a 50^{th} percentile male with the appropriate dimensional, inertial, center of gravity, center of buoyancy and joint properties. The swim physical properties were taken from several proven manikins, including the Hybrid II, Hybrid III, and Advanced Dynamic Anthropomorphic Manikin (ADAM). SWIM has a self-contained data acquisition system (DAS) with 32-channel capability which translates the SWIM movement from 21 joint sensors, 4 pressure transducers, linear and angular accelerations into engineering units. Collectively, these data describe the SWIM's movement in the water environment.

Validation of the SWIM and the WAFAC program was the first important step in the process of developing each as a tool. Preliminary testing was completed at the Institute for Marine Dynamics (IMD) in St. Johns, Newfoundland, Canada, in February and March of 1999. IMD has testing tanks with wave-making capability and is part of the Canadian National Research Council, the primary science and technology agency for Canada. Testing included center of buoyancy (CB) measurements, center of gravity (cg) measurements, drag measurements, simple bottom release tests from 7, 5, 4 and 3 meters of depth and wave testing in simple waves. This preliminary testing, exploratory in nature, was to help point out successes and problems with the SWIM and WAFAC model. Some mechanical and sensor problems were identified with the SWIM. There was good correlation between the actual and simulated bottom release tests when using the normal outfit weight for SWIM. Verification of SWIM and WAFAC tools will provide substantial insight into the rough water testing of PFDs. These tools will aid the Coast Guard in developing better testing methods and provide data for the PFD life-saving index. In 2000, additional testing of SWIM will be coordinated through the USCG Office of Boating Safety, USCG Office of Design Engineering Standards, and Transport Canada. SWIM and the WAFAC model may become tools for industry to design, build, and test new life-saving devices.

In addition, these tools may be used for USCG/CCG-type approval testing and evaluation. Using the WAFAC program, manufacturers may be able to simulate a PFD prototype for use in calm and/or rough water environments eliminating actual in-water testing. Swim could be used for actual in-water testing of new life-saving devices without subjecting a human to the hazards of those tests.