SAFETY DURING MOBILITY

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Our efforts during the past year have been in three areas. The first activity has been development of foam cosmetic covers for prostheses and is described in the report on "Cosmetic Covers for Limb Prostheses." The second activity has been cooperation with the VA Prosthetics Center on evaluation of commercially available automotive hand controls and development of standards for these devices. Anton Reichenberger discussed this activity in his report on "Mobility Aids." The third area is development of an automobile driving system for use by a target population which we will characterize as a C 5-6 quadriplegic. This system is to be an economical, reliable, modular, component system that can be standardized in the future by the auto industry. The key concepts here are modularity—which allows use of selected components on a prescription basis at a reduced cost—and standardization by the auto industry.

We began research in this area by enumerating and then analyzing all of the aspects of this driving problem; the task begins with the individual in his wheelchair outside the vehicle and ends when he has reached his destination and has exited the vehicle. Analysis in this manner allowed us to recognize four broad problem areas which could be treated more or less independently. The first area is the entry-exit system, which in turn relates to the type of vehicle being used; the second area is seating and restraint systems; the third area is the driving task; and the fourth

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area is any additional safety features (foam filled gas tanks to contain fuel in case of rupture, communication systems, etc.).

Fortunately, some of the problem areas have already been addressed. Dr. Cunningham's electric wheelchair, with its special features of variable height, floor lock, and shoulder harness, appears to be well suited for people desiring to drive a vehicle without having to be bodily transferred to the driver's seat. The vehicle selected is a van with a side-entry sliding door. This type vehicle is currently being used by many individuals who drive from a wheelchair by using hand controls. Various entry-exit systems are commercially available which consist of electromechanically operated lifts and door opening and closing systems, and some of these are adequate for our purpose.

By using available (or soon to be available) components for entry-exit and seating, we were able to concern ourselves primarily with the driving task. This task we further divided into operation of primary control systems and secondary control systems. Primary controls are defined as acceleration, braking, and steering. Secondary controls are defined as all other controls necessary for driving the vehicle. The obvious unifying characteristic of this classification is that the primary systems are all vital to safe driving. However, from an engineering point of view the primary controls all require proportional controllers in contrast to the secondary controls which require only on-off switches, or at most multiposition switches. Once the driving task is broken down in this manner it becomes obvious that one should automate as many of the secondary controls as possible, so that the disabled driver can concentrate his capabilities on operating the primary controls. For example, we have developed a "rain sensor" which automatically controls the windshield wipers.

In June of 1973 we received a van and began to transform the concepts which we just discussed into actual hardware. A brief description of the van as it is currently configured follows. The primary controls are operated by a two-axis joystick which drives hydraulically powered steering, pneumatic braking, and mechanical acceleration. All normal controls are retained and either the normal or joystick system can be used.

Secondary systems are now available for control of ignition, lights, windows, wipers, and emergency brake. In addition to the above hardware required for driving, we have installed instrumentation to measure and record all of the primary control inputs (accelerator position, brake position, and steering position) and the resulting vehicle responses (distance,speed, and acceleration). This instrumentation will be used in an evaluation of the primary control system.

The joystick control system has been qualified to date by using this system to pass the Texas Department of Public Safety driver licensing test by a normal driver using the joystick controller. The vehicle is very

controllable at both city and highway speeds and a minimum amount of training is required. We have not yet had any disabled drivers; however, we are scheduled to have the necessary entry-exit equipment commercially installed this month to give us the minimum for driving by the target disabled driver population.

We plan to concentrate in the coming year on evaluation and improvement of the existing systems and addition of backup components to insure a fail-safe system. Evaluation will consist of first evaluating the vehicle performance and then attempting to determine the best man-machine interface for operation of the primary controls by a C 5-6 quadriplegic. Experiments were conducted during the past year with 50 disabled subjects to compare various joysticks for a tracking task. For the driving task we will compare a small joystick, similar to that on an electric wheelchair and installed in a crash-pad-type dashboard, to a cradle or splint-type device which will be attached to the arm to allow control by more gross movements of the shoulder and arm. A second objective for the coming year is to interact with the major auto manufacturers in an attempt to elicit their cooperation in making this equipment available in standard vehicles for both quadriplegics and normal drivers, since we feel that many of the automated units offer increased satety to the general population as well as to the disabled.