It is likely that you will experience a disability at some time during your life that makes it difficult to perform tasks necessary for earning an income. The disability may be temporary, such as a broken leg or sprained knee, or a permanent disability such as arthritis, paralysis, or amputation.

While workers in many industries can be reassigned to other tasks following a disability, farmers often do not have this option. When a farmer is unable to perform necessary tasks, the choices are to rely on other family members, hire someone else to do the work, or to leave the work undone. However, depending upon the disability and the tasks to be performed, properly designed workplace modifications may allow the farmer to continue doing many of the tasks and keep the farming operation running.

The Tennessee AgrAbility Project helps farmers continue performing necessary farming operations by assisting in the development of modifications to farming practices, structures, and machinery in order to allow them to perform the necessary tasks. The AgrAbility Project adaptive tractor controls demonstrator provides examples of modifications for varying levels of disabilities and varying degrees of complexity and costs.

**DISCLAIMER:** The University of Tennessee Agricultural Extension Service provides technical assistance to aid machinery owners in developing controls modifications, but for liability reasons Extension does not design, fabricate, and install machinery controls modifications. The modifications illustrated on this demonstrator are intended only to illustrate possible approaches to off-road machinery accessibility for individuals with disabilities. Each situation involving controls modifications is unique to the individual and the machine involved. Safety and reliability must be ensured during the design, fabrication, installation, and operator training phase. All machinery and structures modifications should be designed by qualified engineers. Only licensed and experienced professionals should design and install controls modifications on cars, trucks, and other highway motor vehicles.

**Basic concepts:**

There are several concepts to keep in mind when planning workplace modifications. Properly selected assistive technologies and workplace modifications aid the person with a disability in performing the desired tasks safely and efficiently. However, if there is a possibility that others will also use the workplace and the equipment, keep the following concepts in mind:

- Safety and reliability must be given proper consideration. All modifications to machinery, structures, and work practices must be designed to prevent unexpected failure.
- Operation of the controls must be logical and follow accepted practices. For example, the direction of motion to activate controls on farm machinery should comply with the design standards and recommended practices published by
the American Society of Agricultural Engineers (ASAE), Society of Automotive Engineers (SAE), and International Standards Organization (ISO). For example, standards state that the lever of a hand clutch should be pulled toward the operator to disengage the clutch.

- Modifications to the machinery controls to accommodate a disability should permit use of the “normal” controls by other individuals. For example, installation of hand levers or actuators for the clutch and brakes should not interfere with normal use of the pedals.

- Of lesser importance is retaining the resale value of the machinery. Avoid cutting, drilling, and welding that will deface the machinery or unnecessarily reduce the resale or trade-in value of the machine. If parts must be removed, save them so they can be reinstalled later.

**Key extension:**

Arthritis is one of the most common and most costly disabilities in America. One problem faced by people with arthritis is difficulty gripping small objects. A simple key extension, made by bolting a strip of PVC to the key, makes the key easier to grip and operate. In fact, the key in the demonstrator can be operated without gripping it at all. Other similar modifications might include fitting larger handles or knobs on controls, replacing a pull knob with a larger knob, or replacing a pull knob with a loop or ring that can be easily pulled without a firm grip.

**Hand clutch:**

One of the most important and most used controls on the tractor is the clutch. It would be difficult or impossible to perform many farming operations without the use of the clutch. For this reason, clutch control modifications are among the most common requests for assistance related to farm machinery.

The demonstrator hand clutch utilizes a simple mechanical linkage to rod that is activated by the clutch pedal. The handle is \( \frac{1}{2} " \) bar stock that was heated and bent to conform to the console and to provide an ergonomic angle for the grip. An angle iron bracket supports the hand lever, and a short lever extends forward under the console. Ball joint tie rod ends and a \( \frac{3}{8} " \) rod connect the lever to the existing clutch linkage behind the console cover. It is important that the handle, mounting brackets, and linkage be of sufficient strength to prevent bending or other failure during use. Effort to pull the clutch lever is approximately \( \frac{1}{4} \) the effort necessary to depress the clutch pedal. Because the linkage is solid, the hand clutch and clutch pedal on the demonstrator always operate in unison.

**Spinner knob**

A steering wheel spinner knob can provide better steering control for individuals with little grip strength or prosthetic devices. Modern tractors with power steering require little
steering effort, but a variety of disabilities make gripping a normal steering wheel difficult. Yet, many individuals can maintain sufficient grip of a spinner knob to effectively control the tractor.

A modified spinner knob, known as the “tri-pin” knob, has three pins extending upward from a plate that replaces the usual knob. A person with minimal grip strength can place the hand between the pins and with the fingers curved around one of the pins, and the pins prevent the hand from slipping. Tri-pin knobs can be used reliably by individuals with prosthetic hands.

**Power assist for 3-point hitch control**

The effort required to operate the control levers of some tractors is excessive. As an example, over 30 pounds of force was required to pull the 3-point hitch control lever to the highest setting on one farmer’s tractor. The excessive effort was the result of the geometry of the linkages used to adapt a cab to a tractor that was most likely also produced as an open platform model. The excessive effort (more than 30 pounds) and an injury to the right shoulder made it impossible for the farmer to operate the 3-point hitch using the right hand. He had been reaching across and operating the control with his left hand – an inefficient, if not unsafe, tractor operation practice.

A 12 volt DC linear actuator was installed in the cab to provide powered movement of the 3-point hitch control lever. Directional control is provided by a rocker switch mounted on the control lever. Pressing on the upper end of the switch causes the actuator to pull the control lever back, raising the lift arms. Pressing on the lower end of the switch reverses the actuator and lowers the lift arms. By placing the switch on the control lever, the farmer is able to determine the height of the lift by the position of the control lever.

Because the actuator can exert 500 pounds of force, it is necessary to provide a means to prevent damage to the tractor’s controls. The actuator for the farmer’s tractor was selected and mounted so that the actuator stroke reaches its limits before the control lever can be damaged.

Limit switches and relays are used on the demonstrator to stop the actuator at predetermined settings. The upper limit is slightly before the control lever reaches its maximum height. The lower limit switch is mounted on the adjustable depth control stop.

Speed of operation using standard linear actuators is acceptable, though not nearly as fast as a quick flick of the lift control lever with the hand. An optional high speed motor is available if faster operation is desired, but it would be difficult to make small adjustments in lift height using the faster actuator.

**Fingertip braking control**

The most complex control modification on the demonstrator is the fingertip controlled braking system. This modification was developed to illustrate the potential for remaining productive in agriculture following more serious disabilities such as paralysis or amputations. The design criteria for this modification required that only off-the-shelf components that are readily available can be used, and that the entire system must fit the tractor without defeating normal operation.

Independent braking is accomplished by depressing the two spring-loaded linear potentiometers
(variable resistors). As each potentiometer moves, it delivers a 0-10 volt DC voltage signal that is proportional to the distance the finger depresses the button. The voltage signal commands an electrically controlled air pressure regulator to change its output pressure, thus extending and retracting an air cylinder to apply and release the brakes.

The major challenges in designing the braking system were sizing and locating the air cylinders so they will not interfere with normal operation of the brake pedals, and mounting them in the space limitations of the tractor cab. The simplest mounting scheme would have been to mount the cylinders in the floor of the cab so that they push the brake pedals forward. However, this placement would interfere with operators who can push the pedals using their feet. While simple pin connections could permit disconnecting the cylinders and pivoting the out of the way for “normal” operators, failure to connect or disconnect them prior to operation by the person with a disability would result in an unsafe condition.

The demonstrator uses air constant air pressure applied to the base end of the air cylinders to depress the brake pedals. This pressure is controlled by a standard air pressure regulator, and is set to the pressure necessary to fully apply the brakes.

Braking control is accomplished by air pressure applied to the rod end of the air cylinders to pull the pedals back to the top of their strokes. This air pressure is controlled by the fingertip controls and electropneumatic pressure regulators. The air pressure supplied by the electropneumatic pressure regulators is proportional to the 0-10 volts delivered by the potentiometers. The electric circuit is designed to supply 10 volts when the plungers are released, and 0 volts when fully depressed.

A “fail safe” operating mode was designed to mimic the operation of air brakes used by heavy duty trucks. Truck air brakes use air pressure to release the brakes, not to apply them. In other words, if air pressure is too low, as in a hose failure, the brakes are applied.

If there is a loss of the control signal to the braking system on the demonstrator, the electropneumatic pressure regulators interpret this as having the control buttons fully depressed, and air pressure will be released from the rod end of the cylinders, resulting in the brakes being fully applied.

A toggle switch allows the tractor operator to set the brakes, freeing the hand to operate other controls if necessary, such as when hitching, starting the PTO, etc.

In the event of a brake control system failure, air supply pressure can be released manually, releasing the brakes so the machine can be driven back to the shop for repairs.

“Normal” operation of the brakes is possible without any changes because the air pressures on the cylinders are adjusted so that the forces pushing the pedals down are balanced by the forces pulling the pedals up. The constant, automatic air pressure adjustments of the electropneumatic pressure regulators ensures that the system can function properly.

Air pressure for the braking system is supplied by an inexpensive hobby air compressor rated at 1.3 cubic feet per minute at 100 psi. Because the displacement of each cylinder is about 6 cubic inches, a small compressor is adequate (1 cubic foot equals 1,728 cubic inches). A 12 volt DC to 120 volt
AC power inverter provides power for the compressor in the field, although the compressor is plugged into the building’s electrical system for most demonstrations. Added benefits of the power inverter and compressor are the ability to operate other 120 volt appliances, and the availability of compressed air for inflating tires and other purposes.

**Other desirable machinery modifications:**

There are many other potential modifications that can improve accessibility and usability of machinery for anyone, disabled or not. A few of the potential uses of aftermarket products and modifications include:

- Improved seating for increased comfort and health through reduced jostling and vibration. Modern seating systems incorporate quality air or spring and shock absorber suspensions and cushions. A fore-aft attenuator that allows the seat to slide back and forth on the base can greatly improve ride comfort and reduce fatigue when operating in rough conditions or pulling implements that result in uneven travel speeds. A swiveling base reduces the need to twist in the seat to monitor equipment. Other quality seating system include adjustable arm rests and back rests.

- Additional or improved steps and handholds improve safety when entering and exiting the tractor. A common tractor modification is to replace the factory steps with a new set of steps having a lower bottom step and at least one additional step. Some tractors have the bottom step as high as 24 inches or more from the ground, which is far too high for most people. A step height of 16 inches is much easier to reach, and reduces the tendency to jump when climbing down from the operators station.

- Extensions for controls can reduce the effort necessary for operation of the tractor. While it may not be possible to relocate the controls themselves, it may be possible to modify the control handles by bending or adding extensions to reduce the reach and effort required to operate the controls.

- Additional mirrors can be mounted inside or outside the cab to increase visibility to the rear and minimize the need to turn the head or twist in the seat to monitor operations behind the tractor. Another possibility for monitoring equipment is to take advantage of low cost closed-circuit television to monitor equipment.

**References:**


AgrAbility Quarterly Newsletter (each issue discusses a category of disability or assistive technology products). [http://www.agrabilityproject.org/newsletter](http://www.agrabilityproject.org/newsletter). National AgrAbility Project, Madison, WI.


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To learn more about AgrAbility:

The Tennessee AgrAbility Project is a cooperative effort of The University of Tennessee Agricultural Extension Service, Tennessee State University Cooperative Extension Program, Easter Seals in Tennessee, Special Technology Access Resource Center and East Tennessee Technology Access Center and various other agencies and organizations interested in helping people with disabilities. AgrAbility’s partners work with the farmers, farm workers, and their family members to comprehensive...
services and develop practical solutions to their needs.

To learn more about farming with a disability and how AgrAbility helps farmers, farm workers, and their family members that have disabilities contact any of the following:

**National AgrAbility Project:**
http://agrabilityproject.org
866-259-6280 (toll free)

**Tennessee AgrAbility Project:**
http://tnagrability.org
866-248-1747 (toll-free)

**UT Agricultural Extension Service, Biosystems Engineering & Environmental Science Department:**
http://bioengr.ag.utk.edu
865-974-7266

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