NDIA 3rd Annual Intelligent Vehicle Systems Symposium & Exhibition

Design and Evolution of Hand Controllers

David Sulkowski - V.P. Engineering

Measurement Systems Inc.

June 11th, 2003

INNOVATION THROUGH EXPERIENCE

Ultra ELECTRONICS

Design and Evolution of Hand Controllers

AGENDA

A. Introduction .

B. Definition of a Control –

Grip / Transducer / Base.

C. Hand Controller Design.

1. Basic Categories.
2. Envelope Sizes.
3. Degrees of Freedom.

Design and Evolution of Hand Controllers

AGENDA

C. Hand Controller Design continued.
   4. Deflection Angle.
   5. Typical Grip Switchology.
   6. Switch Hat / Knob Design.
   7. Output choices.
   8. Transducer Technology Design types.

D. Future trends

A. Introduction

- **Hand controller evolution and utilization goes back well over 75 years. One will find hand control applications in both commercial as well as defense industries. Typical Hand Control applications in the Defense Arena are : *In Simulation Training, In Fighting Vehicles, Mission Controls, Flight worthy Controls, and lastly Unmanned Vehicles.***

- **Today's discussion will focus on basic principles associated with controller design.**

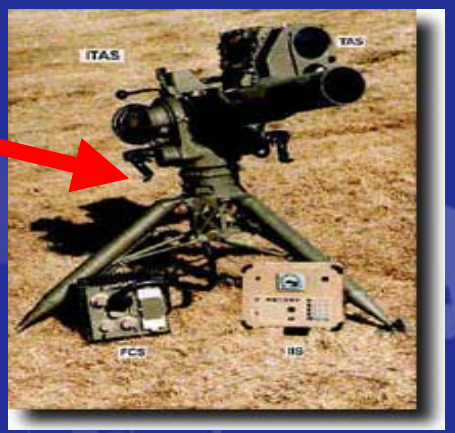
B. Definition

- A Hand controller is defined as an electro-mechanical product that provides a Human Machine Interface solution to the operator.

- It allows the user to control the function and direct the activity of the application. This activity can vary from a controller that directs a Turret through input force.

B. Definition

- **To a hand controller which incorporates a rotor and locking mechanism offering a Human Machine Interface application to direct and control the function of a Laser Range Finder and an Infrared Thermal Acquisition Surveillance Target.**



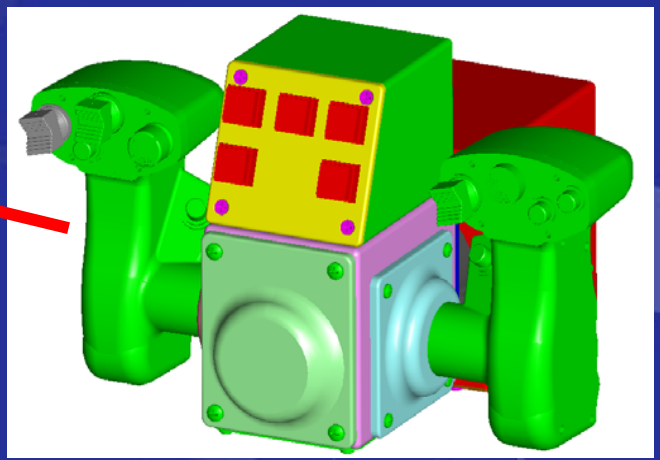
B. Definition

- To a hand controller cursor input device utilized by the FAA to control and monitor Flight takeoff and landings.

- To a controller utilized by a pilot to control , drive, and land a manned / unmanned fixed or rotary wing aircraft.

B. Definition

- To a gunners style hand controller system which can direct and drive an armored manned or unmanned vehicle.



Ultra ELECTRONICS

B. Definition

- The design of a hand controller is made up of three basic sub-assemblies which are :
- The Grip Assembly.
- The Base Assembly.
- Transducer /or drive assembly.

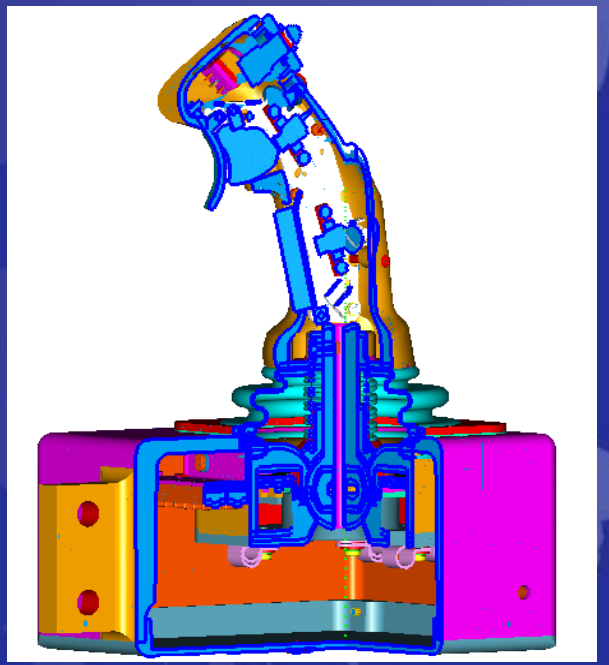
B. Definition

- **The Grip Assembly performs the function of allowing the operator to interface with specific vehicle application. Grips must be ergonomic in shape to properly be used in a field application and not cause undue operator fatigue. Grip Shape can vary tremendously on application. This is due typically to envelope constraints and mission functions. Grip population or switch content increases with added functions. There are two main parts to a grip . The grip body and the grip head. The body of the grip allows for the operator to have a hand hold and control it. The grip head is designed to accept various switch content.**

B. Definition

- **The Base Assembly primarily performs the following functions of:**

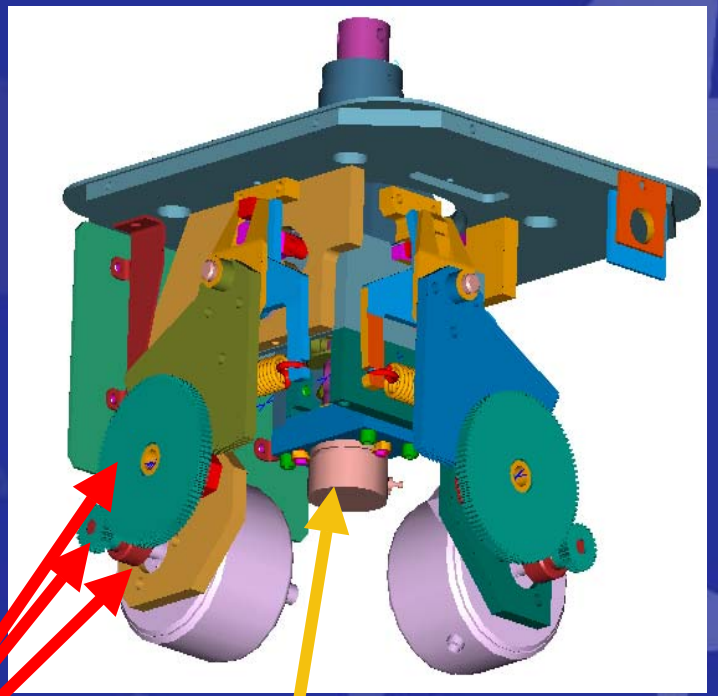
Housing the drive mechanism.
Encapsulating the electronics required for serial output.
Provides location for electrical system connection.
Platform to secure grip.
Method to mount and secure to system.



B. Definition

- **The transducer Drive Assembly translates human input force into an output for the vehicle. Typically it is housed within the base assembly .**

- **Historically Drive mechanism of hand controls were controlled by potentiometers, gear and shaft mechanical assemblies.**



C. Hand Controller Design

- 1. Categories: There are two primary types of hand control input devices. The first is Force Displacement. The second Is Force Non-Displacement.

  Force Displacement controllers typically are used to control devices where a resultant physical displacement is desired such as in vehicle control.

  Force Non-Displacement or stiff stick controllers are used to control devices where physical displacement is not required or physical space limitations exist. Typical example is in a turret control.

C. Hand Controller Design

1. Categories continued:

Force Displacement Controllers		
Force Displacement Joystick	Force Displacement Commanders Control	Force Displacement Gunners Control
		

C. Hand Controller Design:

1.Categories continued:

Non Displacement Force Controllers	
Force Joystick	Non Displacement Force Controller in Y Direction (Stiff Stick)
	

Ultra ELECTRONICS

C. Hand Controller Design

- 2. Envelope Sizes: Envelope Size is somewhat dependent upon added function and content. Typical envelope dimensions for applications are as follows:

Controller Type	Application	Base Length x width x height	Height	
			Grip	Overall
Force Displacement Gunners Control		3.39” square	5.67”	8.29”
Force Displacement Commanders Control		6.5” x 5.38” x 3.65”	7.25”	10.9”

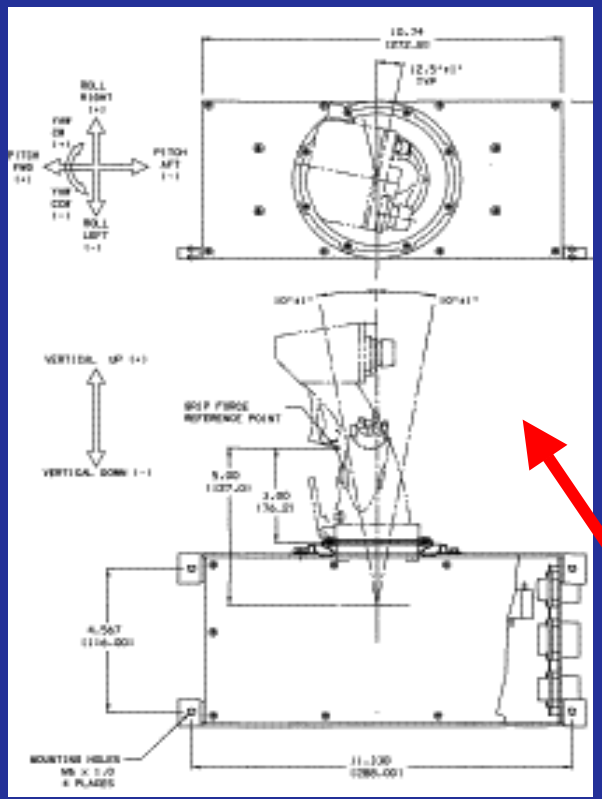
C. Hand Controller Design:

- 3. Degrees of Freedom. A typical commander control will utilize 2 degrees of freedom; +x / -x and +y / -y axis.

- A Typical gunners control will also utilize 2 degrees of freedom +/- azimuth and +/- elevation axis.

- These are basic industry standards.

C. Hand Controller Design:

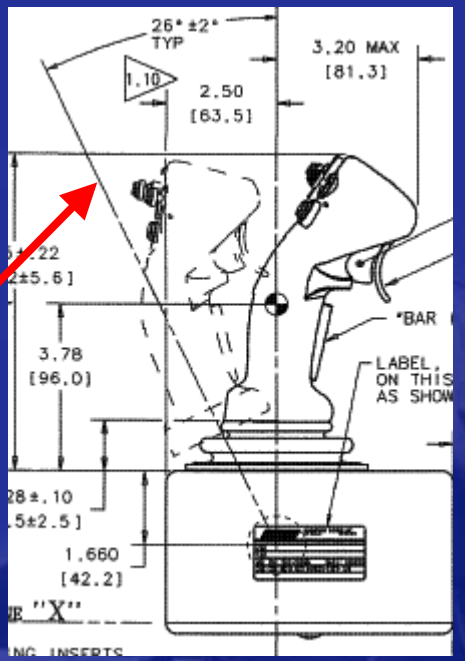


- **3. Degrees of Freedom continued:**

  The Design of the number of degrees of freedom for a hand control may vary widely for the application, with a range from Zero degrees of freedom for a stiff stick to 4 degrees of freedom for a commander with twist axis and up and down z as shown.

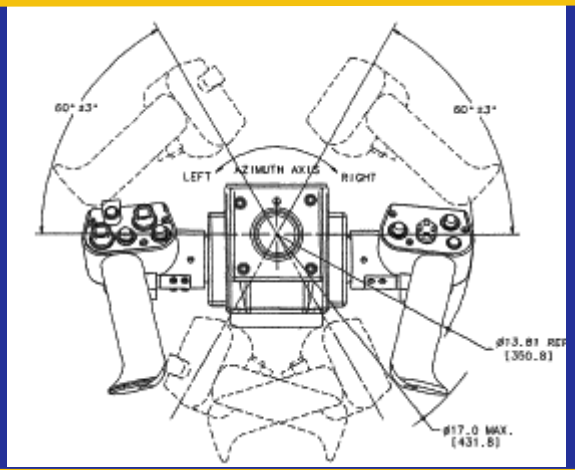
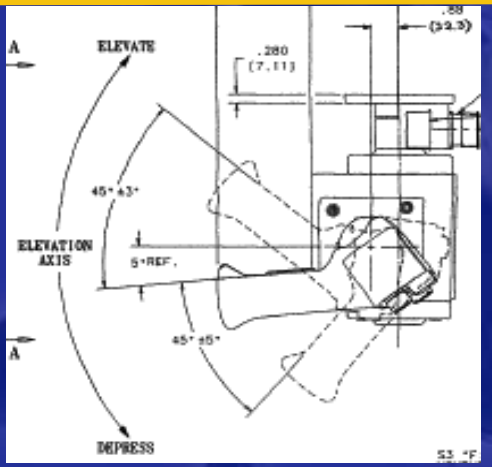
C. Hand Controller Design:

- 4. Deflection. A typical force displacement *COMMANDER'S* control will utilize a 28 degree deflection angle in both x and y axis. Most applications fall in the range of 15 to 28 degrees for a commander force displacement hand control.



C. Hand Controller Design:

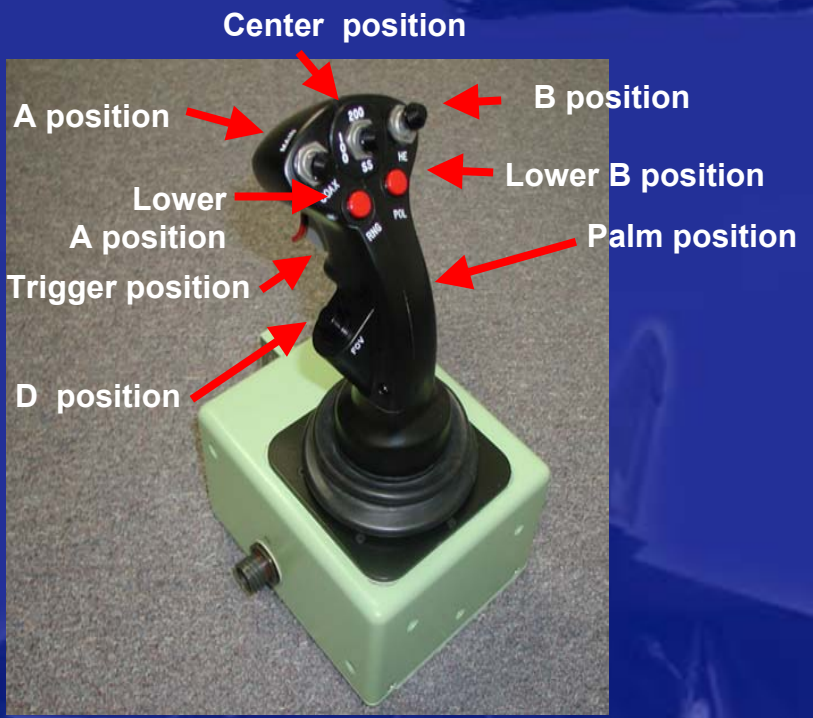
- 4. Deflection continued. A typical force displacement *GUNNER'S* control will utilize a 60 degree deflection angle in the azimuth and 45 degrees deflection in the elevation axis.

Azimuth	Elevation
	

Ultra ELECTRONICS

C. Hand Controller Design:

- 5. Switchology. Switch location in a commanders grip is typically referred to as: A position, B position, Center Position, D Position, Lower A, Lower B position, Palm switch.



- Specific Type of switches are typically used in these locations. A&B = pushbutton , 3 or 4 way toggle center = joystick , D = pushbutton, trigger = single or double detent.

C. Hand Controller Design:

- 6. Knob / Hat Design. Switch knob design choices are a function of application location and switch function within the hand controller. Most common choice is a pushbutton in black or red color. After this the next most typically used are: Coolie hat, Castle top, Boat Switch, Inverted boat switch.

C. Hand Controller Design:

- 7. Output : Serial Output for a typical Commander or Gunners Force Displacement Hand Controller is RS232. Also common but not utilized as much as RS232 are RS 422 and RS485 Serial output.

- Canbus and USB applications in hand controls are available and have also begun to be utilized in applications.

C. Hand Controller Design:

- 8. Transducer Designs : There are two basic transducer base technologies currently available for a commander's and gunner's force displacement hand control.

- The first transducer design features a potentiometer based gear driven shaft design. It is heavy and due to the use of gears as the drive mechanism will wear over time. It can be either a direct drive or indirect drive system.

- The second transducer design features advanced sensor technology. This design choice is non contact and therefore offers higher reliability and MTBF.

C. Hand Controller Design:

- 8. Transducer Designs : Advanced Sensor technology, Hall Effect and or Magneto Resistive, are available in both commander's and gunner's displacement force hand controllers. They offer dual redundancy vs. a potentiometer based design.

D. Future Trends in Hand Controllers:

- **Hand Controllers will: Continue the transition from Potentiometer to Higher Technology .**

Miniaturize - Smaller Packaging of transducer bases due to shrinking envelope size as more and more content is added to the surrounding cockpit.

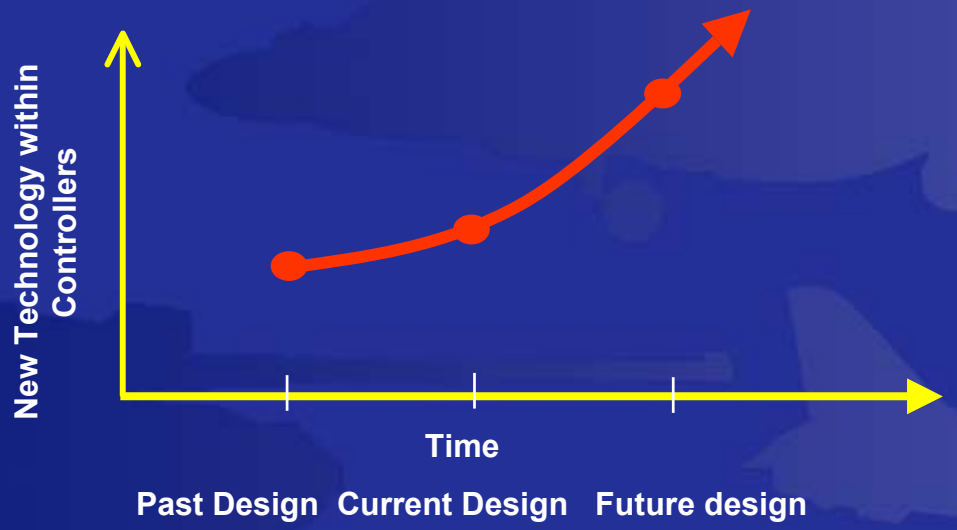
Continue to shed weight.

Continue on the trend to more content and complexity.

Portable controllers.

D. Future Trends in Hand Controllers:

- **1. Incorporate New Technology:**

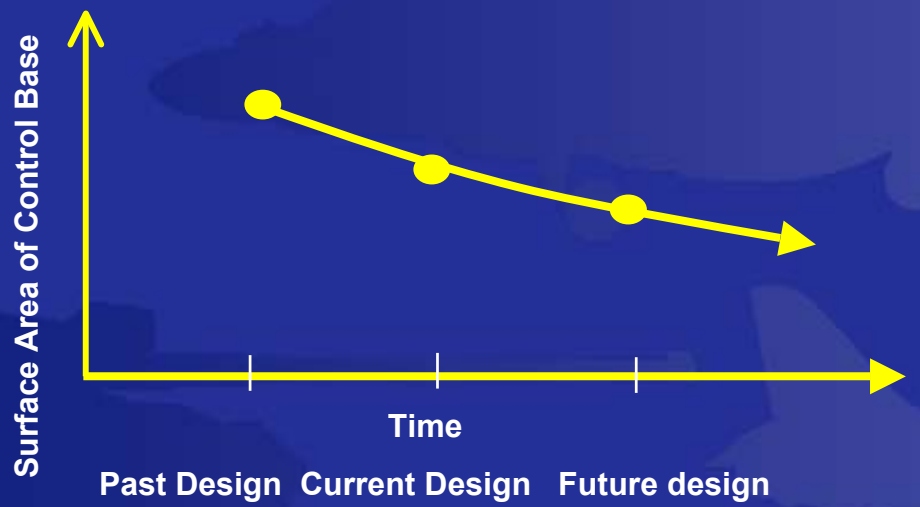


1.] Hand Controllers will continue the Transition from Potentiometer gear driven transducer bases to Higher Technologies such as Hall effect to improve MTBF.

Ultra ELECTRONICS

D. Future Trends in Hand Controllers:

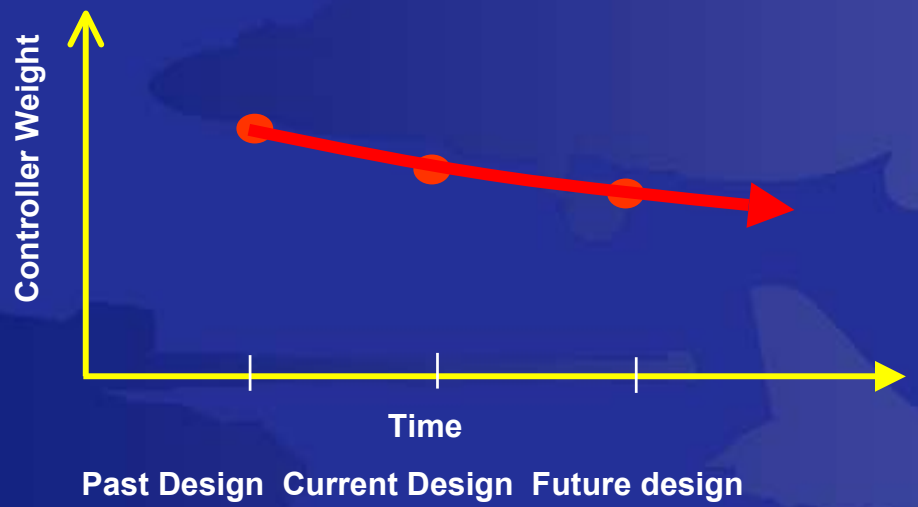
- **2. Miniaturization:**



1.] Trend over Time is a 18 % reduction in Area of the Hand Control base.
2.] Would expect Trend to continue forward into next Generation controllers.

D. Future Trends in Hand Controllers:

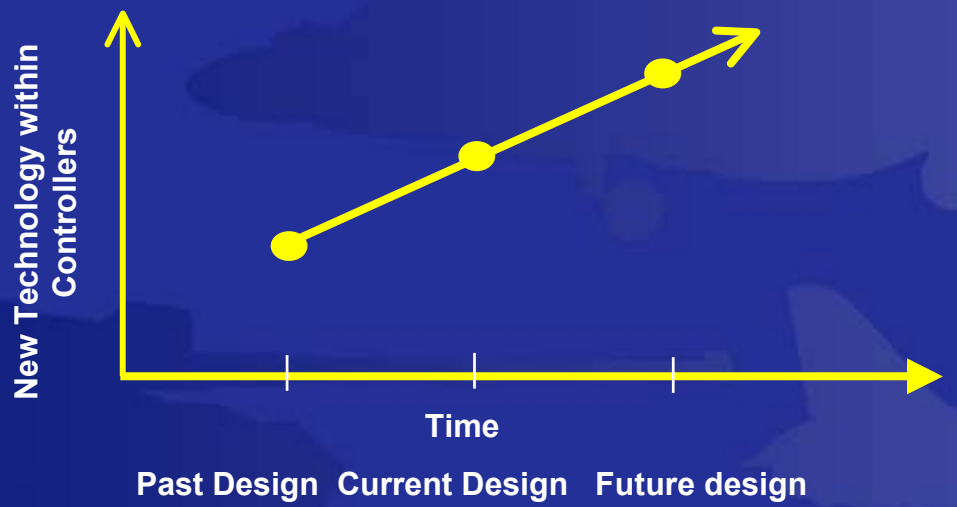
- **3. Weight Reduction:**



1.] Trend over Time is a 12 % reduction in Weight of the Hand Control.
2.] Would expect Trend to continue forward into next Generation controllers.

D. Future Trends in Hand Controllers:

- **4. Increased Functionality / Complexity :**



1.] Hand Controllers will continue to increase content and complexity due to increasing requirements of the mission.

Design and Evolution of Hand Controllers

D. Future Trends in Hand Controllers:

An example :USC (Universal Soldier Control)

- Transportable & Portable
- Wireless Mobile Computer Technology
- GPS
- High Resolution LCD
- Ergonomic layout for easy operation
- Miniature force joystick for Cursor control
- Light weight
- Sealed design for Mil- Std- 810F
- NVG compatible
- Operator Feedback Features

The End.