

**"THE VERTICAL"**

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**ABSTRACT**

"THE VERTICAL" computer keyboard is designed to address critical factors which contribute to Repetitive Motion Injuries (RMI) (including Carpal Tunnel Syndrome) in association with computer keyboard usage. This keyboard splits the standard QWERTY design into two halves and positions each half 90 degrees from the desk. In order to access a computer correctly, "THE VERTICAL" requires users to position their bodies in optimal alignment with the keyboard. The orthopaedically neutral forearm position (with hands palms-in and thumbs-up) reduces nerve compression in the forearm. The vertically arranged keypad halves ameliorate onset occurrence of keyboard-associated RMI. By utilizing visually-reference mirrored mylar surfaces adjustable to the user's eye, the user is able to readily reference any key indicia (reversed) just as they would on a conventional keyboard. Transverse adjustability substantially reduces cumulative musculoskeletal discomfort in the shoulders. "THE VERTICAL" eliminates the need for an exterior mouse by offering a convenient finger-accessible curser control while the hands remain in the vertically neutral position. The potential commercial application for "THE VERTICAL" is enormous since the product can affect every person who uses a computer anywhere in the world. Employers and their insurance carriers are spending hundreds of millions of dollars per year as a result of RMI. This keyboard will reduce the risk.

**ERGONOMICS AND RMI/CTD**

The understanding of ergonomic factors for computer workstations is a relatively new area of research and application. The word 'ergonomic' explains the interaction of people to their environment and only first appeared in the workplace in the early 1980s with regard to the meat-packing industry. Although the need for ergonomic office furniture and furnishings has been recognized since 1986, due to the rapid increase of Repetitive Motion Injuries (RMI) and Cumulative Trauma Disorder (CTD) at computer workstations, modifications have been slow in coming. This is due to the perceived high-cost factors to the employer and the absence of governmental regulations.

During 1991 and 1992, media sources focused on business owners who had a difficult time paying for rising insurance costs due to increased workers' compensation claims for non-accident related injuries. The media began concentrating its attention on ergonomic solutions to work environment problems other than the computer keyboard. They blamed the computer industry, the video display terminal and lag time by a majority of employers, who over the past decade have used technology to double production, but have failed to protect the worker using that technology. By mid-1992, full media attention was focused on the recognition that the traditional computer keyboard design was the primary cause of repetitive motion injuries for computer keyboard users.

Repetitive motions (keystrokes) are an essential part of a computer operator's work function. According to the Bureau of Labor Statistics, repetitive motion injury claims, such as Carpal Tunnel Syndrome, have grown at an alarming rate over the last decade. These injuries can cost employers \$30,000-\$80,000 in health insurance, sick pay, disability, and workers' compensation benefits per incident.

The complete QSR data collection system consists of a handheld Pen-Based computer utilizing Pen for Windows as the operating system. This system collects and stores data in a flat ASCII format on the PCMCIA card. At the end of each shift, the QAS will extract the PCMCIA card and place it in an external drive that is located at a stationary workstation. This data will then be uploaded to the network, and appended to the centralized database which stores all QSR data.

#### Testing and Validation:

System testing and validation was accomplished over a four month period by running the Pen-Based computers in parallel with the paper forms. The data from both systems was compared to make sure that it had not been corrupted or lost.

#### Training:

Pen-Based computers are extremely user-friendly and requires minimal training. System training at KSC will be conducted in two phases: Pen-Based unit familiarization and forms entry. It is designed to provide QAS personnel with "hands-on" experience, and will be required prior to certification.

## CONCLUSION

Pen-Based computers are extremely versatile and can be used to automate virtually any data collection process. They can be tailored to unique requirements, integrated with any computer system, and networked for data exchange. Their use at KSC for the data collection, transfer, and storage process has greatly improved management decision support. Delays in shuttle processing related to data deficiencies have been reduced significantly. Pen-Based computers have been extremely useful in streamlining the NASA Quality Data Program and will be further utilized in other paper processes at KSC and other NASA centers..

## ACKNOWLEDGEMENTS

The data collection, Pen-Based computer system has been developed with the funding from NASA (contract NAS10-11675).

## REFERENCES

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3. Deputy Director Gene Thomas, "Recycling at KSC," Spaceport News, January 15, 1993, p. 3.
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## CARPAL TUNNEL SYNDROME

The major RMI problem with which most people are familiar is Carpal Tunnel Syndrome (CTS). CTS is caused by repetitive, forceful, quick and uninterrupted tasks common to computer keyboard operators. The carpal tunnel, which runs through each wrist into the hands, houses the median nerve and nine tendons which control movement of the thumb, forefinger, middle finger and half the ring finger. The tunnel is formed by the carpal bones on the back of the hand and the transverse carpal ligament on the palm. Repetitive keystroking can cause swelling around the tendons, which puts pressure on the median nerve, causing pain and reducing hand function. The physical condition of the keyboard operator may accelerate CTS and quicken the onslaught of pain. This is especially true for many women who, during pregnancy, hold on to body fluids and are prone to bloating at the wrists. When overdone, other outside activities such as tennis and knitting may also accelerate CTS.

Pronation, the twisting of one's wrist so the palms are facing downward, while working on the keyboard, has been identified by medical and orthopaedic specialists around the world as a major cause of Repetitive Motion Injuries. Employees working at computer workstations are potential victims of RMI. The immediate focus are the individuals who work on computer keyboards for extended periods of time each day. Workers in this endangered class are employed by federal, state and local governments, major corporations, large industries and major service organizations which interact with other public and private companies. Their jobs may consist of six to eight hours of data input per day without proper breaks for exercise and stretching. Many orthopaedic physicians recognize the severity of the problem, and have developed specific exercise programs which may help combat Carpal Tunnel Syndrome for computer operators. Unfortunately, these are only band-aids to the real problem of improper hand and body positioning.

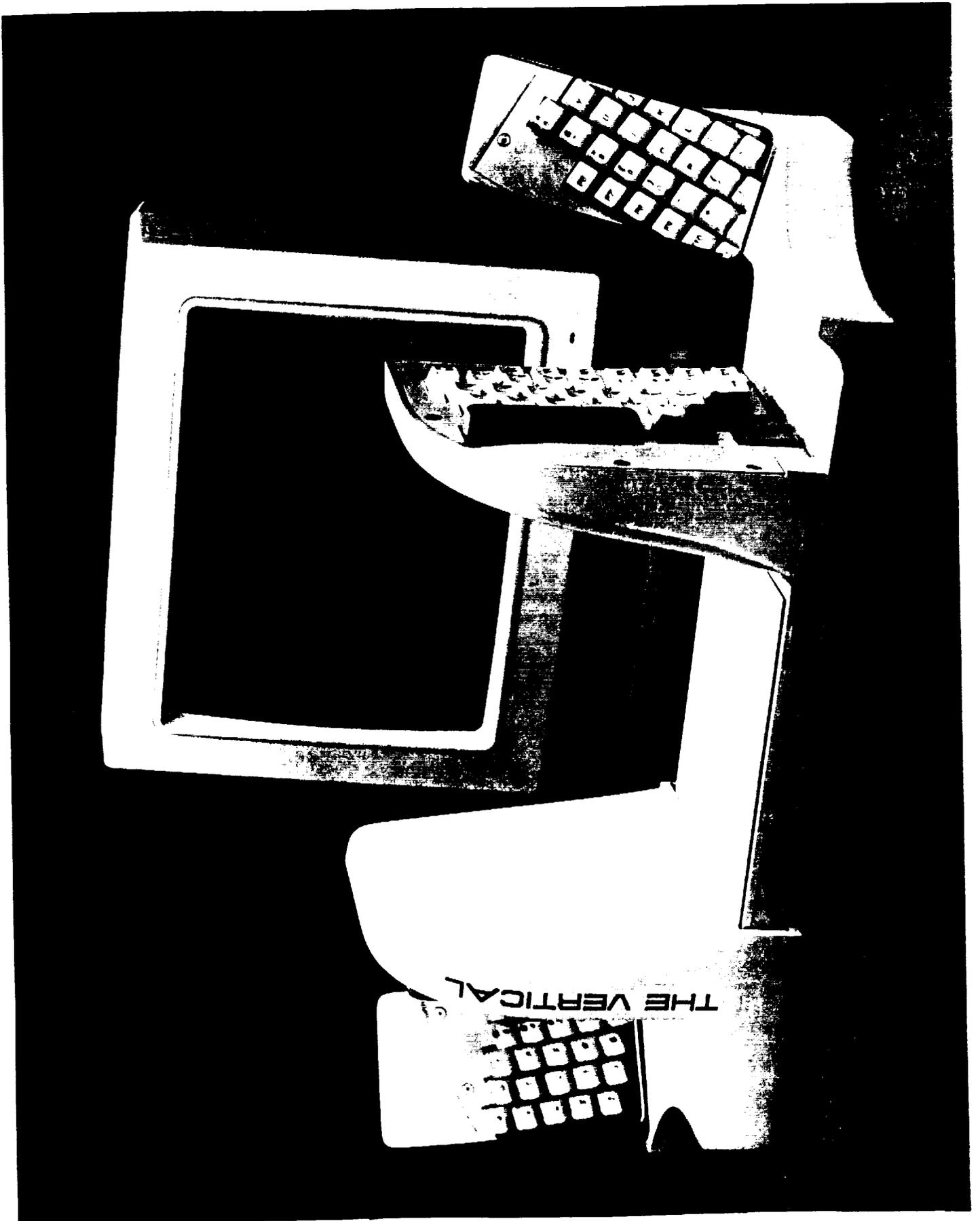
## COMPUTER COMPANY EMPHASIS

Computer companies and manufacturers have always placed their primary focus on the production of faster and more reliable computers and ignored the physical needs of computer operators. They have produced inexpensive keyboards which, instead of being "value-added", are considered "commodities" which unfortunately must be included to operate the computers. Even in the sight of emerging class action lawsuits (charging computer and keyboard companies with negligence in continuing to manufacture products detrimental to users), the companies have ignored the evidence and continued to manufacture ill-designed keyboards.

It must be realized the large percentage of office workers who have developed RMI from computer keyboard usage did not grow up with computers. RMI occurred over the last 10 - 15 years due to the extensive use of computers in the work environment. However, children are growing up using computers from a very early age. If the keyboard design is not corrected, RMI will affect many more people in epidemic proportion at a much earlier time in life.

## "THE VERTICAL"

"THE VERTICAL" keyboard, designed and developed by Ergonomic-Interface Keyboard Systems, Inc., in La Jolla, California, is patent protected in the United States and patent pending internationally. Its design has received endorsements from hand surgeons and clinical orthopaedic therapists as well as from OrthoMed, the Hand Rehabilitation Center of the University of California, San Diego Medical Center. "THE VERTICAL" is the only ergonomic keyboard which UCSD has approved for testing with its patients.





Beyond the constant barrage of media attention regarding RMI such as Carpal Tunnel Syndrome, the demand for "THE VERTICAL" is evident from the scores of letters, phone calls and faxes from around the world received by The Company since the first few magazine and newspaper articles about it appeared in October of 1992. Many inquiries are from safety engineers and ergonomic experts representing large corporations who understand the problem in the industry and view "THE VERTICAL" as a viable solution. Inquiries from federal, state and local governmental agencies have been received and are awaiting production of the final manufactured units. International companies have requested information on terms the Company would require for them to become manufacturing and distribution arms.

## THE MARKET

No product could have a more ready-made market than "THE VERTICAL". RMI is a major world-wide health problem. Employers, and their insurance carriers, are spending literally hundreds of millions of dollars per year as a result of RMI. The product is the most eagerly sought item in the computer-related industry; a keyboard which preliminary judgment leads us to believe should substantially reduce the risk of RMI (including Carpal Tunnel Syndrome).

Based on Standard & Poors October 1991 Industry Surveys, not including keyboards from Apple, Omega, Tandy, etc., there are seventy-five million IBM and compatible keyboards in the United States. With well over one hundred million (100,000,000) keyboards in use in the U.S. market alone, each one utilizing an ill-designed keyboard, the market for a "value-added" keyboard is obvious. Penetrating fifty percent (50%) of the existing market would mean selling over fifty million (50,000,000) keyboards in the United States alone. Conceptually however, the market area for a correctly designed ergonomic computer keyboard is throughout the world, and the U.S. portion of that is under twenty percent (20%).

## ORTHOPAEDICALLY OPTIMAL KEYBOARD FACTORS

The words "ERGONOMIC KEYBOARD" have been used to identify a few new keyboard designs recently developed by individuals who are not employed by computer and keyboard companies. However, those words do not determine the degree of healthfulness for the user. Our extensive research and work with orthopaedic surgeons and clinical rehabilitation therapists has shown the optimal progressive ergonomic keyboard:

- Encourages optimal seating positioning (MOST IMPORTANT)
- Eliminates pronation (downward rotation of the hand and forearm)
- Eliminates arm/shoulder flexion (extending upper arm forward from shoulder)
- Adjusts to the user's torso width
- Reduces transitional motion (removing hand from keyboard to use a mouse)
- Accommodates the shape and movements of user's hands,
- Increases productivity / decreases fatigue

"THE VERTICAL" is designed to address critical factors causing RMI in association with computer keyboard usage. In order to access a computer correctly, "THE VERTICAL" requires users to position their bodies in optimal alignment with the keyboard. The orthopaedically neutral forearm position (with hands palms-in and thumbs-up) eliminates hand and forearm pronation, which reduces nerve compression in the forearm. The vertically arranged keypad halves serve to ameliorate onset occurrence of keyboard-associated RMI by eliminating the extremes of wrist flexion (up and down movement of the wrist), shoulder and arm extension and ulnar deviation (outward rotation of the wrist). By utilizing visual-reference mirrored mylar surfaces adjustable to the user's eye, the user is able to readily reference any key indicia (reversed) just as they would on a conventional keyboard. Transverse adjustability (movement like an accordion to a locked position) to user's torso width substantially reduces cumulative musculoskeletal discomfort in the shoulders while reducing wrist deviation. "THE VERTICAL" eliminates the need for an exterior mouse by offering a convenient finger-accessible cursor control, while the hands remain in the vertically neutral position resulting in increased productivity through less transitional motion.

Patients who have experienced discomfort on traditional computer keyboards have found relief when using "THE VERTICAL". Further research with keyboard users showed individuals, and especially industry, will not accept a product which forces them to relearn the keyboard or takes extensive amounts of time to regain normal speed and accuracy. Based on the comments of hundreds of people who have interfaced with "THE VERTICAL" prototype, an average touch typist will regain speed and accuracy within hours.

## COMPETITION

"THE VERTICAL" will compete with other companies which develop and market ergonomic computer keyboards, some of which are of greater size and may have greater financial resources. Ergonomic-Interface Keyboard System Inc.'s major competitors are the manufacturers of new "ergonomic" keyboard styles. However, those new keyboard styles which allow the user to pronate their hands and wrists during keystroking, maintain a "flat" keyboard similar to the major manufacturers, thereby incurring the same potential problems to the user. Others stray from the standard QWERTY key configuration and eliminate traditional typing formats altogether. They insist the user learn a new operational language in order to operate the board. Since, over the years, other unconventional keyboards such as the Dvorak System have been introduced yet have not been accepted by industry due to the need of retraining the user, it is felt by industry experts any keyboard which strays from the QWERTY format will not be accepted by the masses. One of the competitors states the optimal, ergonomic keyboard operates with the user's hands in a vertically oriented position, yet their keyboard does not offer the user that possibility without eliminating the visual connection from the user to the board. Existing major computer keyboard manufacturers and major computer companies which manufacture their own keyboards are not considered competition due to existing lawsuits against them stemming from their ill-designed "flat" or "conventional" keyboards.

Competition exists between the Company and some ergonomic experts who ignore the physical problems which the computer keyboard has been accused of creating. Their opinion is with proper body positioning and the correct use of properly designed ergonomic furniture, the problems of RMI and CTD could be eliminated. This is not the opinion of most medically and/or orthopaedically trained physicians. It does not address the damage keystroking plays on the user's body while the hands and wrists are pronated and arms are projected forward from the shoulders. Body position and furniture type alone cannot correct RMI and CTD problems. However, the Company does agree proper body positioning and the correct use of properly designed ergonomic furniture should be utilized while using "THE VERTICAL" so as to enhance the value of the keyboard's design.

Some experimentation has begun with hand written data entry, but this has limited application at best (for limited use by physically disabled operators, etc.). The error factor is also a serious problem with hand written data entry.

## FUTURE PRODUCTS

The long term goals of The Company are towards the modification of other data input devices to obtain benefits similar to those of "THE VERTICAL". Adaption of the basic design to meet specialized keyboard styles for governmental and research usage is expected to be an easy transition. Another logical extension of this design, which is now being worked on by The Company, is a vertically oriented Stenograph device.

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## A SYSTEMS APPROACH TO COMPUTER-BASED TRAINING

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### ABSTRACT

This paper describes the hardware and software systems approach used in the Automated Recertification Training System (ARTS), a Phase II Small Business Innovation Research (SBIR) project for NASA Kennedy Space Center (KSC). The goal of this project is to optimize recertification training of technicians who process the Space Shuttle before launch by providing computer-based training courseware. The objectives of ARTS are to implement more effective CBT applications identified through a needs assessment process and to provide an enhanced courseware production system. The system's capabilities are demonstrated by using five different pilot applications to convert existing classroom courses into interactive courseware. When the system is fully implemented at NASA/KSC, trainee job performance will improve and the cost of courseware development will be lower. Commercialization of the technology developed as part of this SBIR project is planned for Phase III. Anticipated spin-off products include custom courseware for technical skills training and courseware production software for use by corporate training organizations of aerospace and other industrial companies.

### INTRODUCTION

Global competition and rapid changes in technology have increased the demand for employee education and job training. There are three major reasons for this increase in demand [1], the first being that displaced workers need to be retrained. It is estimated that most workers will change jobs five or six times during their lives. Due to the dynamic nature of the U.S. economy, 1.5 million workers are permanently displaced each year and require assistance to reenter the workforce. By the year 2000, it is estimated that 5 to 15 million manufacturing jobs will require different skills than for today's jobs, while an equal number of service jobs will become obsolete.

Second, the work being performed at most companies is becoming increasingly complex. The use of computers and more sophisticated business processes require many employees to relearn how to perform their jobs. Furthermore, competition demands that there be constant change in the products and services that companies offer. This causes a ripple effect throughout the company in bringing these new products and services to customers.

Changes in the organizational structure of companies also increase the demand for job training. One result of the difficult economic climate is that many companies are downsizing, increasing the need for cross training of workers. One of the principles of Total Quality Management (TQM) is the expansion of employee empowerment, with teams of employees performing a function or process with little or no direction from traditional management. Companies that are turning to TQM principles are finding that employees are unqualified for this empowerment without a large investment in training.

The United States' educational system fails to prepare many employees for the challenges of the modern workplace. The poor performance of U.S. high school graduates relative to their foreign counterparts on standardized tests is well publicized. Without supplementary training, the level of education of available American workers frequently fails to meet the requirements of employers. A recent study shows that one-fifth of displaced workers lack a high school education and that 20 to 40 percent of these workers are considered functionally illiterate.

Due to changes in the economy and increases in skill level requirements for the workforce, many companies have expanded their employee training programs. Typical employee development programs at many large companies now include remedial training in reading, writing, and basic mathematics. Also, increased quality and safety requirements have caused companies to institute formal job or skill certification programs. However, the increased necessity of workforce training is costly in terms of time away from the job, travel costs to and from training sites, and expenses associated with classroom facilities, instructors' salaries, and administration.